The WHAT'S NEW magazine
MARCH 1986
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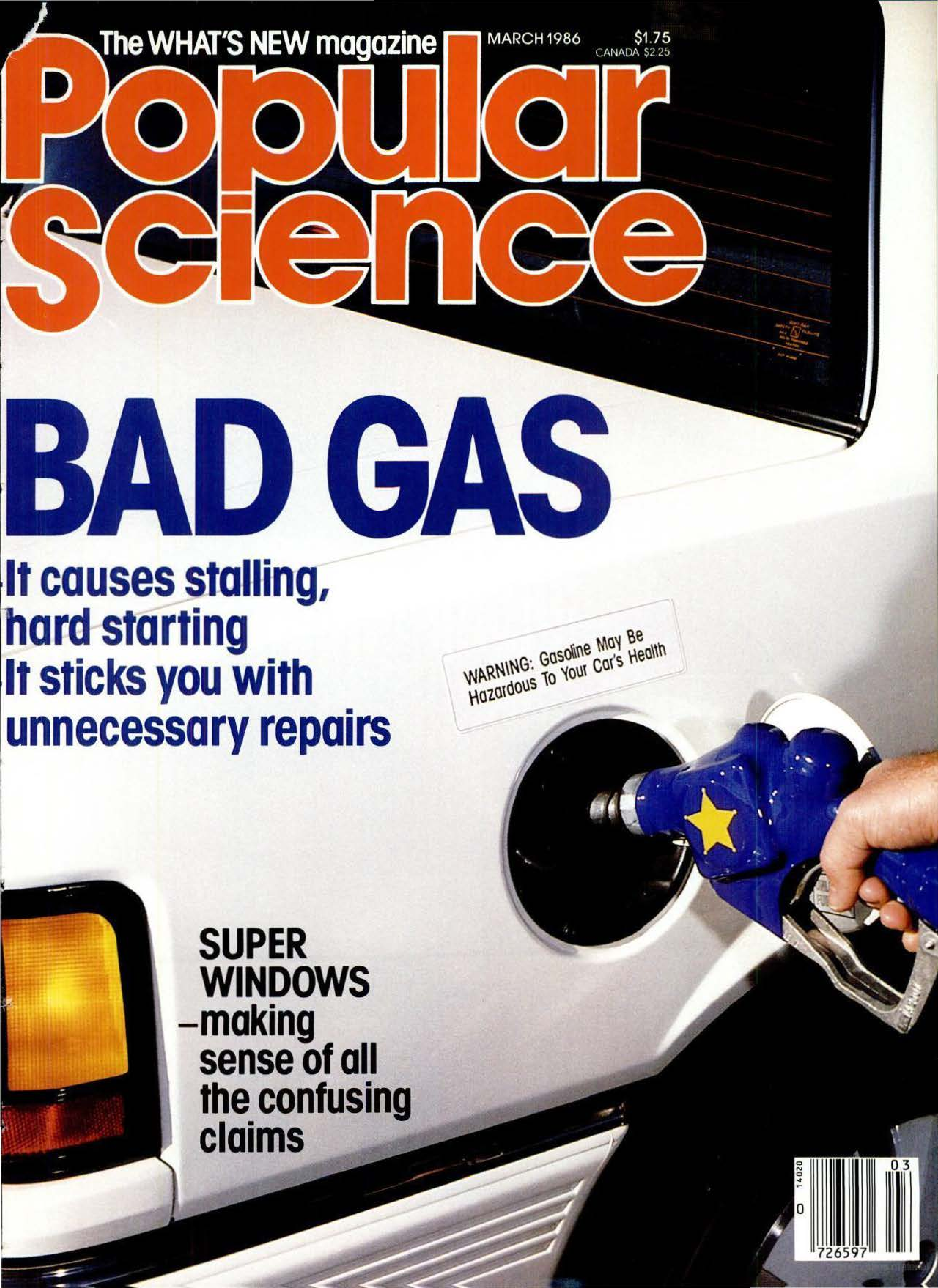
Popular Science


WARNING: Gasoline May Be Hazardous To Your Car's Health

BAD GAS

It causes stalling, hard starting
It sticks you with unnecessary repairs

SUPER WINDOWS

—making sense of all the confusing claims

The classic no enthusiast should be without.

A classic truck? Well, sure.

The pickup is a classic of sorts, with over five decades of service to mankind to its credit. But the GMC S-15 4X4 Pickup is a classic departure from trucks as they are commonly perceived.

Its rakish looks and sophisticated comforts allow this GMC truck to do virtually anything a car can do. And its Insta-Trac four-wheel drive, double-wall cargo box and optional V-6 engine allow our pickup to do a lot of things a car could never do.

The GMC S-15 4X4 Pickup. If you're into fine cars, it's time you discovered fine trucks. Buckle yourself into one soon at your nearby GMC Truck dealer. And please help preserve America's natural beauty whenever you're out four-wheeling.

GMC
TRUCK
A truck you can live with

GM

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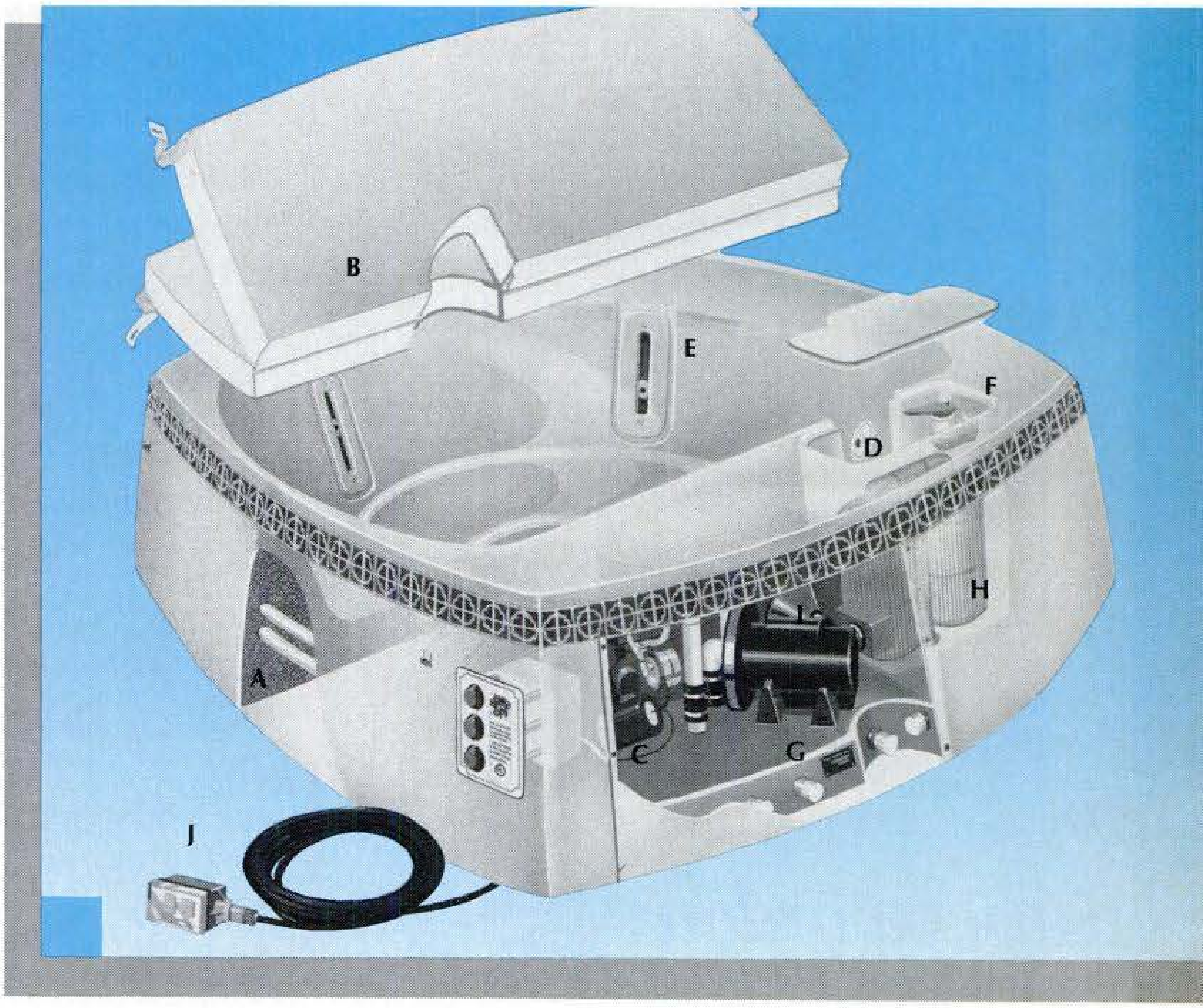
A SPA IS A SPA IS A SPA?

A CONSUMER GUIDE

If you've been considering a spa or hot tub you're probably already aware of the benefits and pleasures of whirlpool massage. However, not all spas and hot tubs are alike. The true test of any spa is whether it can provide these pleasures conveniently and efficiently. We'd like you to know what to look for when shopping for a spa and show you why the engineers who designed the HOT SPRING SPA have produced the best one available today.



1. MATERIALS AND CONSTRUCTION.

The HOT SPRING SPA is made of the most advanced and durable material of any spa—ROVEL™ This high-impact plastic is superior to wood of old fashioned hot tubs because it doesn't absorb water, leak or deteriorate. Unlike fiberglass or acrylic surfaces, ROVEL won't peel, blister, crack or delaminate. Check the warranties of other spas and you'll see that ROVEL is guaranteed to be much more durable than any other spa material. In fact, a recent industry trend has seen many acrylic manufacturers reduce surface warranties to just one year! ROVEL is softly textured so you won't slip when entering or exiting the spa.

2. CONVENIENCE AND EFFICIENCY.

Most spas and hot tubs have very little thermal insulation, some have none at all! Just how important is insulation? It's the most important feature in private spa ownership! Uninsulated spas will physically not operate outdoors in colder climates, making spa use as seasonal as a swimming pool. Further, a marginally insulated spa forces the heater to run continuously, costing you money. The HOT SPRING SPA is FILLED SOLID with over 130 lbs. of polyurethane foam insulation **(A)** and standard equipment includes a 3½″ thick insulating cover **(B)**. This heavy insulation makes it economical to keep the HOT SPRING SPA heated to your desired temperature 24 hours a day, regardless of location. You can use your HOT SPRING SPA at any time day or night, in any weather, and for just pennies.

3. TEMPERATURE.

Precise temperature control is important. A spa should control temperatures within ±1°F. or you'll forever be too hot or too cold as the water changes temperature. The HOT SPRING SPA achieves this accuracy by using a "precise demand" thermostat with its sensor in intimate contact with the water **(C)**.

4. HYDROTHERAPY JETS.

Vigorous jet action is the key to true hydrotherapy. Only the HOT SPRING SPA gives you the option of powerful fixed jets (22 psi at each jet) **(D)**, and the unique massaging effects of MOTO-MASSAGE™ The exclusive MOTO-MASSAGE (U.S. Patent #4,523,340) glides gently up and then down the entire length of your back in a continuous sweeping motion that simulates the natural stroking of a manual massage **(E)**. In addition, we provide an air control which can be reached from inside the spa so you can vary the intensity of the jets **(F)**. These features combined with the STA-RITE Max-E-Glas pump provide the best hydrotherapy available today **(G)**.

5. WATER CHEMISTRY AND FILTRATION.

Most portable spas contain less than 180 gallons of water. It is difficult to maintain proper chemistry in such a small body of water. Therefore it is necessary to drain them more frequently than the HOT SPRING SPA which contains 275 gallons. Good filtration is essential in any spa, but in other portables, it has been overlooked. The HOT SPRING SPA has the largest capacity filter of any portable spa—50 square feet **(H)**. It requires attention only 2 or 3 times a year. Its top-loading design allows you to inspect, remove, and clean it without draining the spa.

6. LIGHT FOR NIGHTTIME USE.

Another feature of the HOT SPRING SPA is the underwater light **(I)**. It's dimmer controlled so it's never too bright or too dim, and different colored bulbs can be used for different effects.

7. NO INSTALLATION.

Simplicity of installation should be checked. An in-ground spa is the most difficult, usually requiring backyard excavation, building permits and an expensive installation crew. Hot tubs are not much simpler. The HOT SPRING SPA avoids these problems by requiring only common household current to operate (110v. 20amp.) **(J)**. There is no permanent hard wire electrical hook-up, no external plumbing to assemble, and no building permits to obtain. As a portable appliance, the HOT SPRING SPA will not increase your property taxes and you can take it with you when you move.

8. LISTED BY UNDERWRITERS LABORATORIES.

The HOT SPRING SPA is completely listed by Underwriters Laboratories, the recognized experts in testing for safety. The importance of correct and safe electrical design should not be overlooked. Check for the U.L. Mark on the outside of any spa you're considering—you'll see it on the HOT SPRING SPA.

We are proud of the quality features we build into every HOT SPRING SPA. The HOT SPRING SPA is an integrated design whose form follows function—the result of 9 years of evolution toward an ideal. So, before you buy any spa, be sure to see and test the HOT SPRING SPA. It has the features, performance, and quality you need.

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Popular Science®
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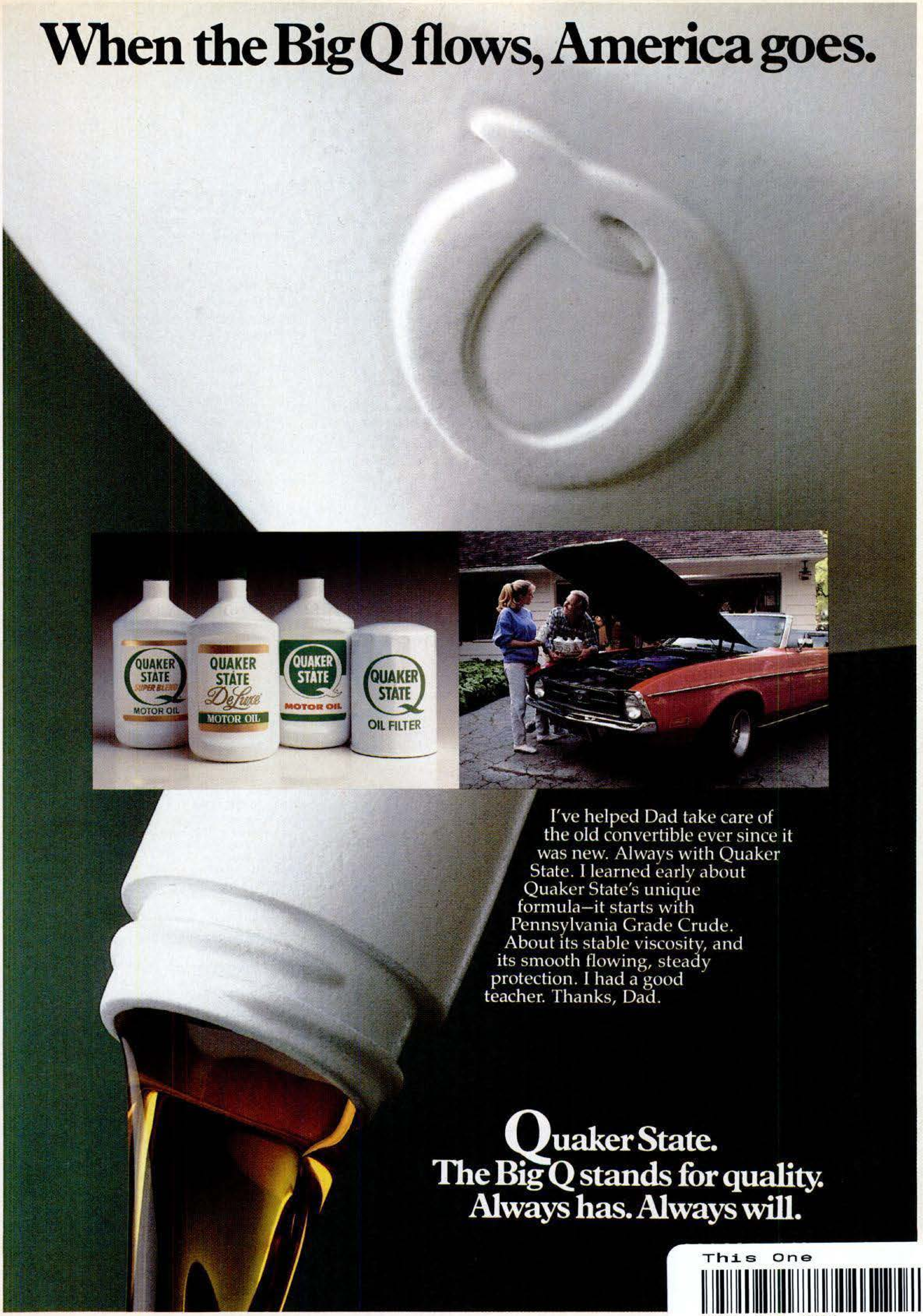
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Readers Talk Back

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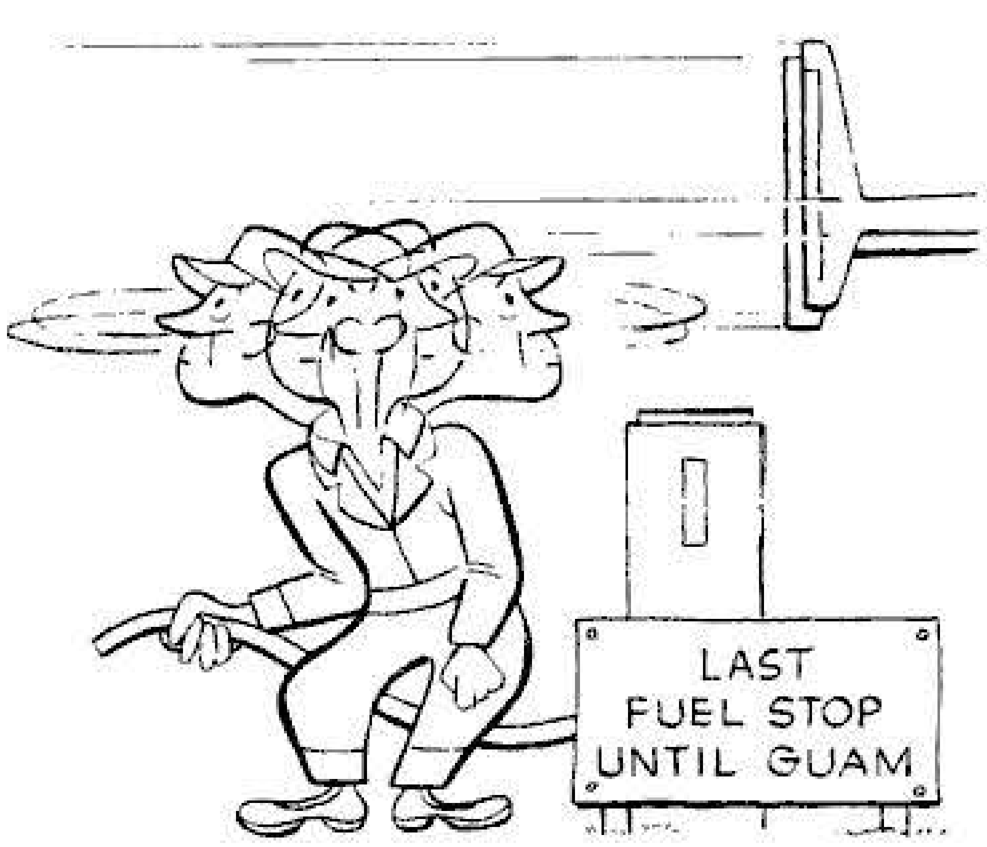
Around the world?

Whatever happened to Dick Rutan's round-the-world flight ["Around the World Without Refueling? Rutan's Ultimate Flyer," Sept. '84]?

Mario Q. Vilella, Rio Piedras, P.R.

Dick Rutan replies: "The avionics and the new engines have been installed.



We've been flight-testing the plane for the first time in a year, and we're in the final phase. I can't say when the Voyager *will be ready to go, but we plan to try for the world fixed-course distance record before we get to the round-the-world record."*

Radon—just a scare?

"Radon Exclusive—How Dangerous" [Nov. '85] said that the government is generally geared to cleaning up man-made, not natural, hazards. But Canonsburg, a small town in western Pennsylvania, is the site of a Department of Energy radon-gas cleanup that's costing millions of dollars.

Also, your article discusses the potential health problems of radon exposure. I suggest that you check the cancer statistics of people living near or in a radon site—you'll find them surprisingly inconclusive.

Thomas P. Haynes, Potsdam, N.Y.

V. Elaine Gilmore replies: "Canonsburg is an unusual situation—the contamination was caused by a scientist bringing uranium home for experiments. The radiation stems from human folly, not natural causes.

"The only study of cancer and radon has been done by Dr. Bernard Cohen. He has found very little correlation between cancer and radon exposure—so far. Cohen, however, warns that his results are preliminary. Until they become conclusive, public health officials will continue to act upon the consensus: Radon is the second-leading cause of lung cancer."

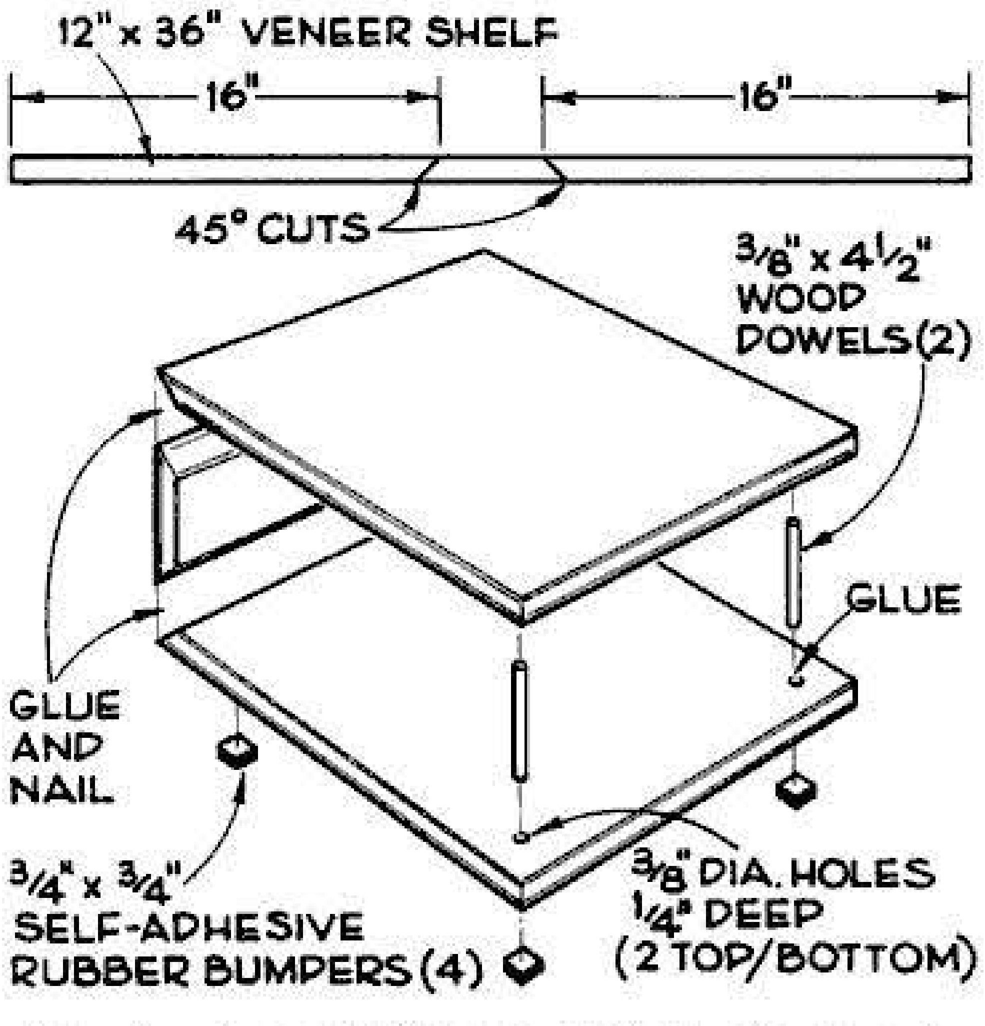
Sleek, cheap printer stand

Those who read "Kill the Clutter: Build This Computer Printer Stand" [Nov. '85] might be interested in the printer stand I assembled for about $13 [see drawing].

To build the stand you'll need a three-foot-long prefinished veneered shelf (the kind that's available at most home-improvement centers), a 3/8-inch wood dowel nine inches long, and four self-adhesive rubber bumpers.

Begin construction by making two 45-degree cuts through the shelf 16 inches from each end. Use a table saw with a finishing blade for the best cuts. The three pieces will form the stand's top, bottom, and one side.

For the dowels, which will form the other side, drill four 3/8-inch holes 1/4-inch deep. Then glue up the stand—I used frame-miter clamps to keep the joints in place—and secure the boards with small finishing nails. When the glue dries, add the rubber bumpers. For a finished look, stain the dowels to match the veneer.


12" x 36" VENEER SHELF
16"
16"
45° CUTS
3/8" x 4 1/2" WOOD DOWELS(2)
GLUE
GLUE AND NAIL
3/4" x 3/4" SELF-ADHESIVE RUBBER BUMPERS (4)
3/8" DIA. HOLES 1/4" DEEP (2 TOP/BOTTOM)

Terry Foster, Vestal, N.Y.

Digital radio

What would have to happen technologically for radio or television stations

Continued

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Readers Talk Back *Continued*

to broadcast in digital? It would be nice to have AM stations broadcast in compact-disc quality.

Mike Beene, Dallas, Texas

William J. Hawkins replies: "Digital broadcasts require two main components: an analog-to-digital converter at the broadcast station and a digital-to-analog converter at your radio. The first converter changes audio signals to digital for transmission; the second converter changes them back to analog for reproduction in a radio. The technology is available and has been used in tests for sending computer programs to users via radio. However, there may be some problems. Among them: For commercial use, all broadcasters and radio manufacturers must agree on a standard system—and they must be willing to pay for the cost of the converters."

Satellite TVs and snow

How well do those new satellite antennas [Dec. '85] work with two or three feet of snow on them? And who wants to go out in deep snow to switch satellites by manually changing an antenna's position? There are plenty of northerners who like their antennas big and capable of motorized satellite tracking.

Harry C. Wiersdorfer, Hamburg, N.Y.

Susan Renner-Smith replies: "Those living in the colder, snowy climes aren't necessarily left out of the latest improvements in satellite antennas. The further north you go, the shallower the angle the dish must make with the horizon. It depends on the satellite, of course, but in many areas of New York state, for example, the angle wouldn't exceed 40 degrees. (If you look at the angles of the antennas on the December cover, you'll see that they're all at a fairly shallow angle). That means a dish won't necessarily double as a snow catcher."

Smart lights and washers

"Now Power and Logic on One IC: The Control Revolution" [Nov. '85] gave the impression that with the proper integrated-circuit chip, a fluorescent lighting fixture could give more lighting (lumens) per hour than what the tube is rated at. How does that work—does the chip increase the life of the tube and ballast? Are chips available that can be connected to existing fixtures (mine are Circline fluorescents)?

Ivan N. LeClair
Needham Heights, Mass.

You say that many engineers would find a five-gallon ultrasonic washing machine prohibitive. Why?

Mark Wenter, Linwood, N.J.

John Free replies: "The article cited an earlier PS article ["Computerized Ballasts Cut Fluorescent-Lighting Costs," July '81] that may hold the answers to LeClair's questions. The latter describes an operating principle for controlling lights, although the circuits are not integrated on a chip. At that time, Thomas Industries of Louisville, Ky., claimed its computerized ballast had 50 percent more capacity than conventional types. Its tests showed that a computerized ballast supplying three lamps required 20 percent less power than the two ballasts required for a standard three-lamp fixture. A variety of firms now market electronic ballasts; anyone interested should contact local dealers.

"In answer to Wenter's washer question: The number or size of ultrasonic transducers needed to agitate that much water might make the washer too costly."

Noble stone

It's always a pleasure to see a new, creative use of a noble material ["Marble Tile Goes DIY," Nov. '85], and I congratulate Alan Shute for his innovative marble installation kit. But I'm a little concerned about the adequacy of support that five small pads of Ultrabond, his specially developed adhesive, will supply a six-inch-square marble tile. As you know, if marble isn't properly bedded, it can break when something lands on it. I'm also curious to know how adhesive Ultrabond remains in exceptionally dry climates like the Southwest.

Robert Hund, Managing Director
Marble Institute of America, Inc.
Farmington, Mich.

Susan Renner-Smith replies: "It may be too early to judge Ultrabond's performance in exceptionally dry climates. But nine months ago, I installed marble tiles on my bar top—which gets considerable traffic—and my kitchen counter. No tiles have been damaged, and they still look great."

Corrections: Photos 4 and 5 in "Fastest Bicycle in the World" [Feb.] were incorrectly labeled. The numbers identifying those two photos should have been transposed.

The Sidekick program for Macintosh computers is $85, not $45 as listed in "Electronics Newsfront" [Jan.].

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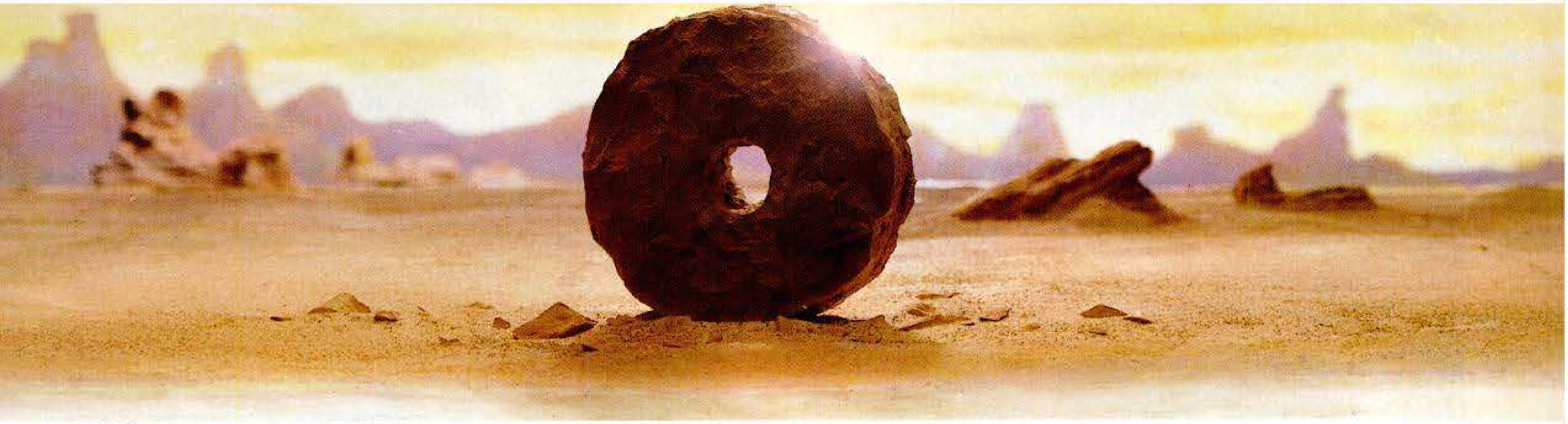

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BDP PLUS 90™ GAS FURNACE

Cut your heating costs dramatically with BDP's super-efficient Plus 90 gas furnace and make your winter warm and comfortable. Our unique heat exchangers (both with 20-year limited warranties) wring extra heat from every Btu of gas.

In fact, because the Plus 90 models are from 92.2% to 97.3% efficient, you'll save 30% to 40% every heating season over older, less efficient furnaces.

The Plus 90 is the quietest, most reliable furnace BDP has ever built. And that's saying a lot because we build more furnaces than anyone. The Plus 90 is easily affordable too. Contact your Bryant, Day & Night or Payne dealer to see just how affordable.

bryant®
day & night®
Payne®

Plus 90
THE ULTIMATE HEATING MACHINE

CALL 800-GET-WARM or send the postage-paid reply card fo

rite way to heat

Year after year, in survey after survey, gas heat is the Number One choice of America's homeowners. Nothing else matches the comfort, fficiency, cleanliness and dependability of gas. And, today's new generation of advanced gas heating systems allows you to enjoy a houseful of warmth from very little gas—making gas heat an even better buy.

CARRIER WEATHERMAKER® GAS FURNACE

Keep comfort up and heating costs down with a Weathermaker gas furnace. Advanced, silence-sealed burner system delivers unbeatable fuel efficiency. Carrier super-streamlined heat exchanger cuts electric bills, too.

The 20-year limited heat exchanger warranty says it: the Weathermaker is built with the quality and dependability you expect from Carrier.

See your Carrier dealer for the Weathermaker model that's right for your home. Get ultra-high efficiency, whisper-quiet performance and space-saving design. Very affordable.

Carrier®

weathermaker sx
Carrier

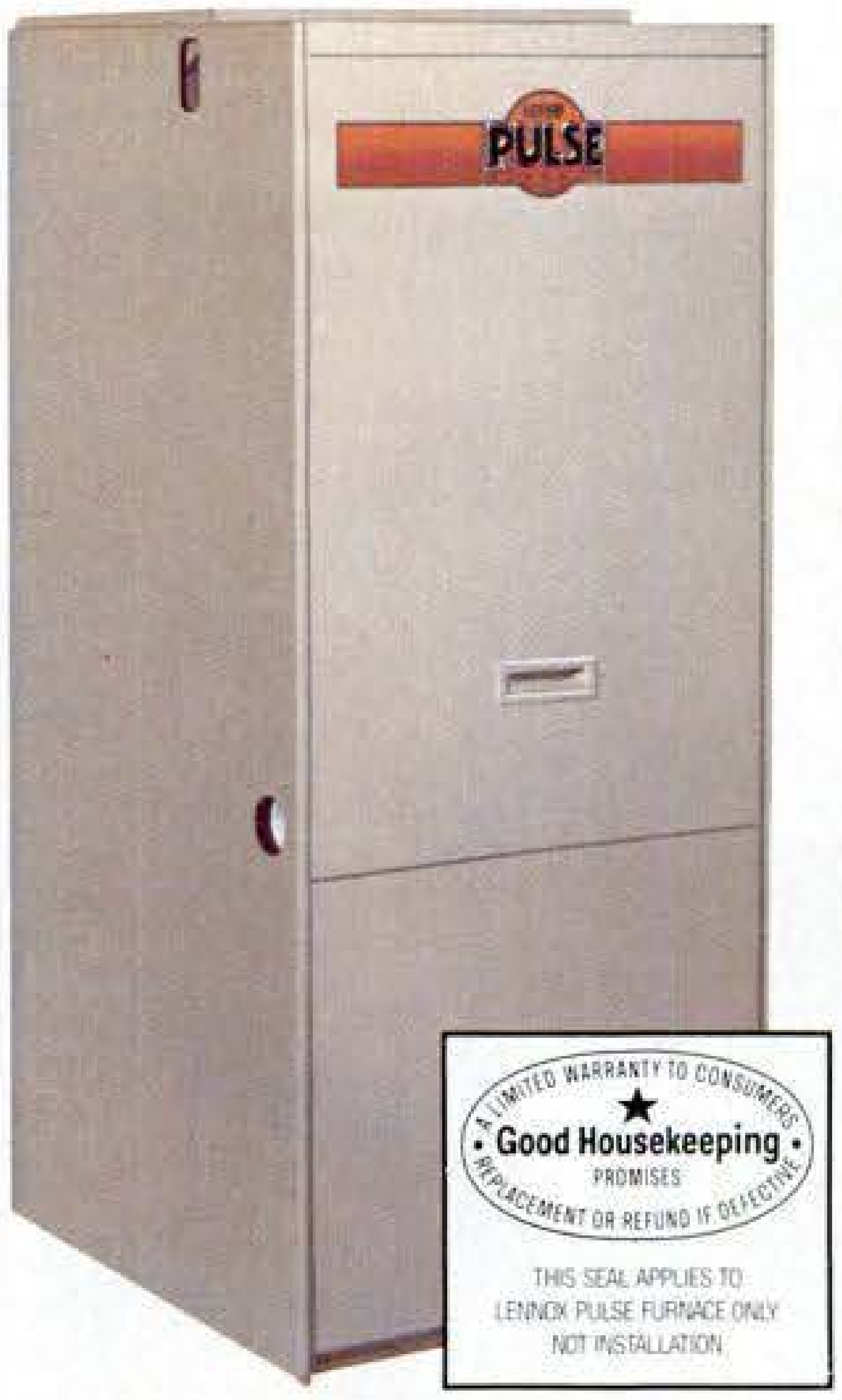
LENNOX PULSE™ GAS FURNACE

The unique Lennox Pulse is a breakthrough in furnace technology. It uses "Pulse" combustion to turn gas into heat with practically no waste. The result? You enjoy total comfort while cutting your fuel use almost in half.

Whatever type of furnace you have now, you can replace it with an energy-saving Pulse. It's so reliable, the heating assembly has a 20-year limited warranty. And the Pulse has earned the Good Housekeeping Seal.

Hundreds of thousands of homeowners are enjoying big savings with the Pulse. So can you. Just see your independent Lennox dealer.

LENNOX®


PULSE
A LIMITED WARRANTY TO CONSUMERS
Good Housekeeping
PROMISES
REPLACEMENT OR REFUND IF DEFECTIVE
THIS SEAL APPLIES TO LENNOX PULSE FURNACE ONLY NOT INSTALLATION

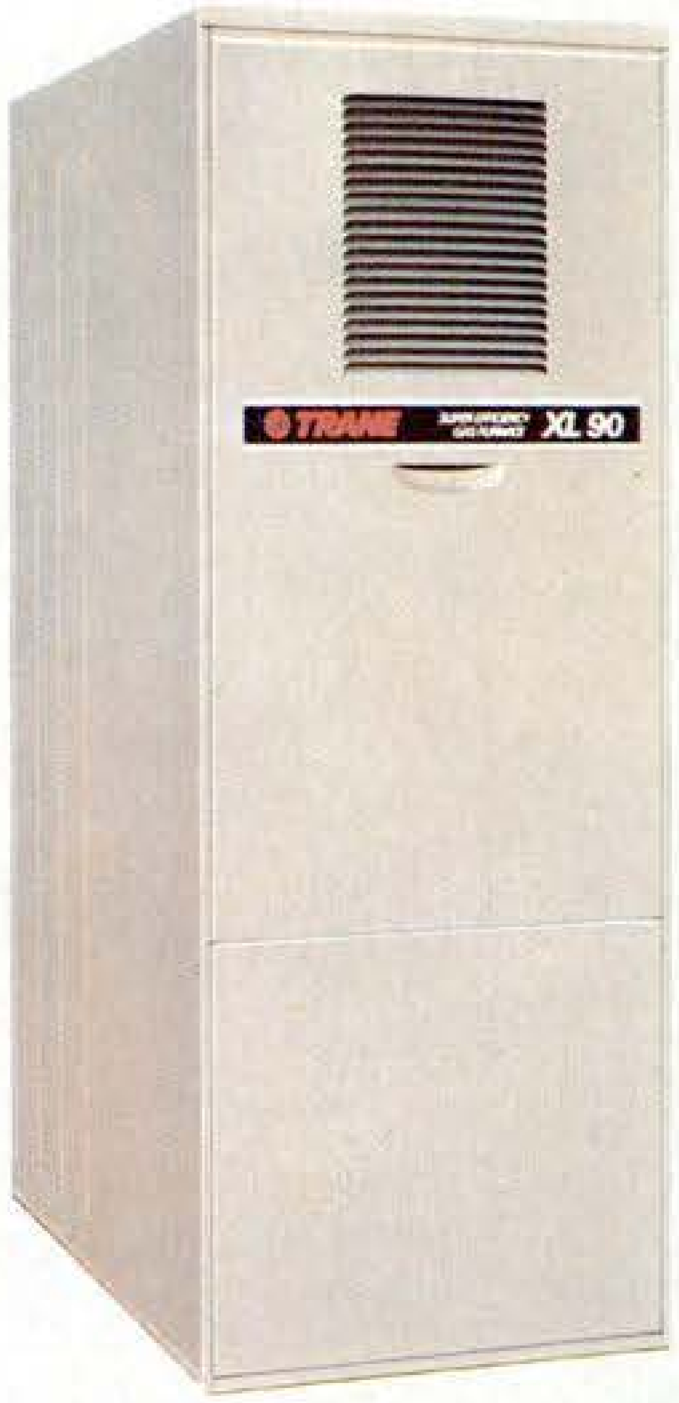
TRANE XL 90 GAS FURNACE

Trane's newest high-efficiency gas furnace can significantly reduce your home's fuel consumption. The XL 90 delivers a houseful of comfort from less gas thanks to its specially designed 29-4C Stainless Steel Coil that captures the heat older style furnaces lose up the flue.

There's an XL 90 model to match your home's heating needs. It's easy to install and backed by a 20-year limited warranty.

Your Trane dealer can show you how much you can save—and how quick the payback—with this superb fuel economizer.

TRANE™



nore information.

Gas. America's best energy value.

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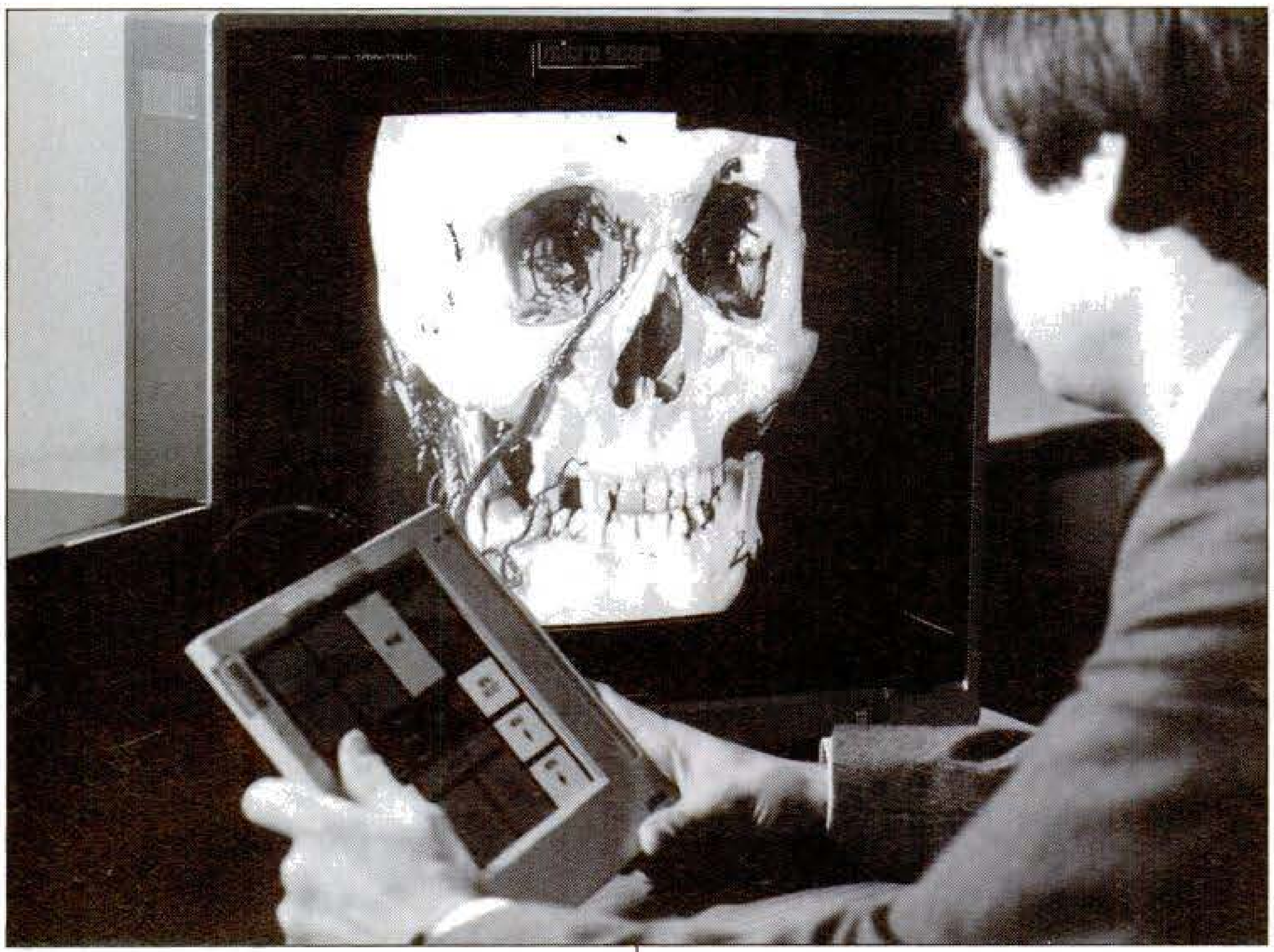
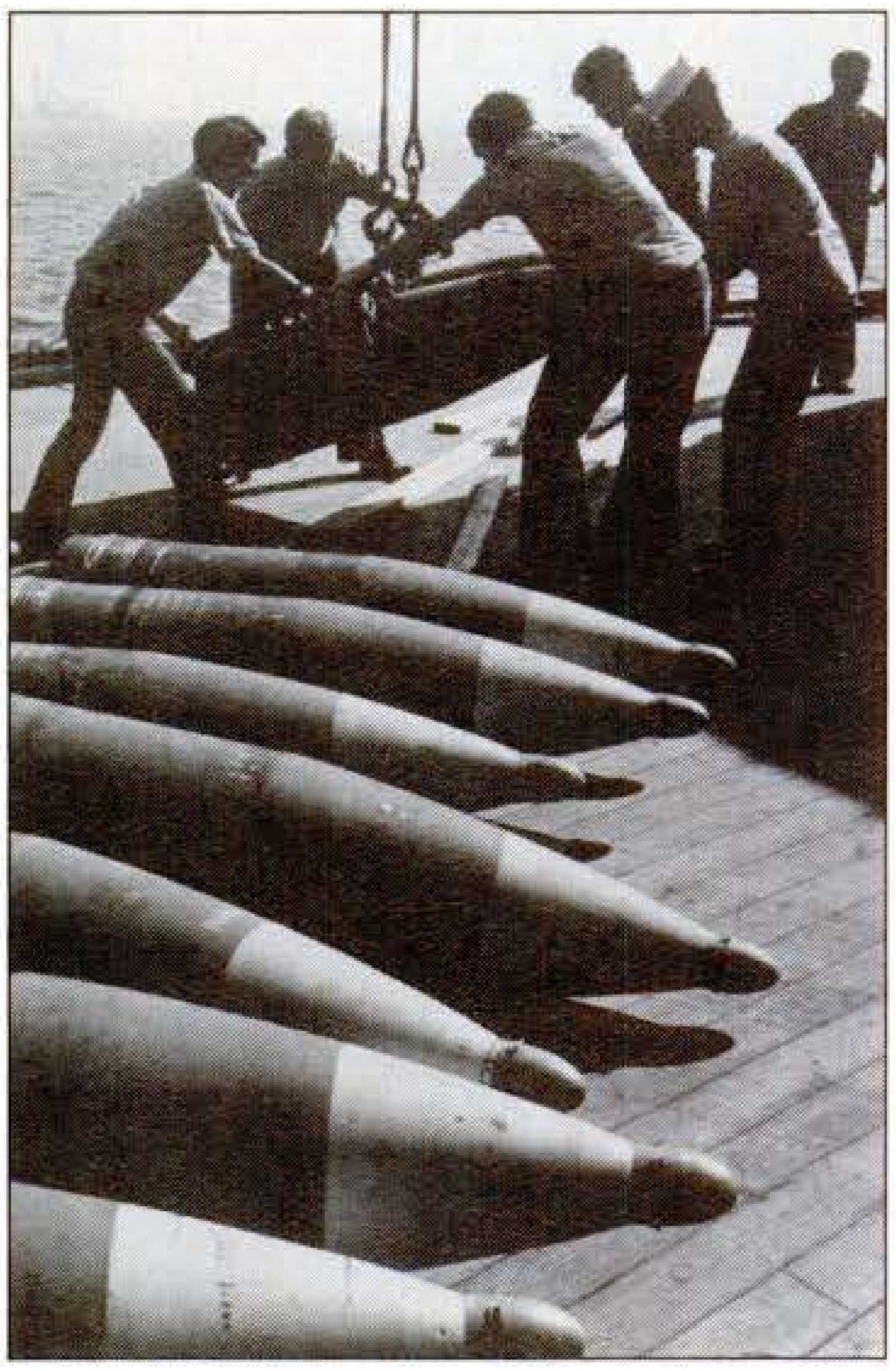
Science Newsfront

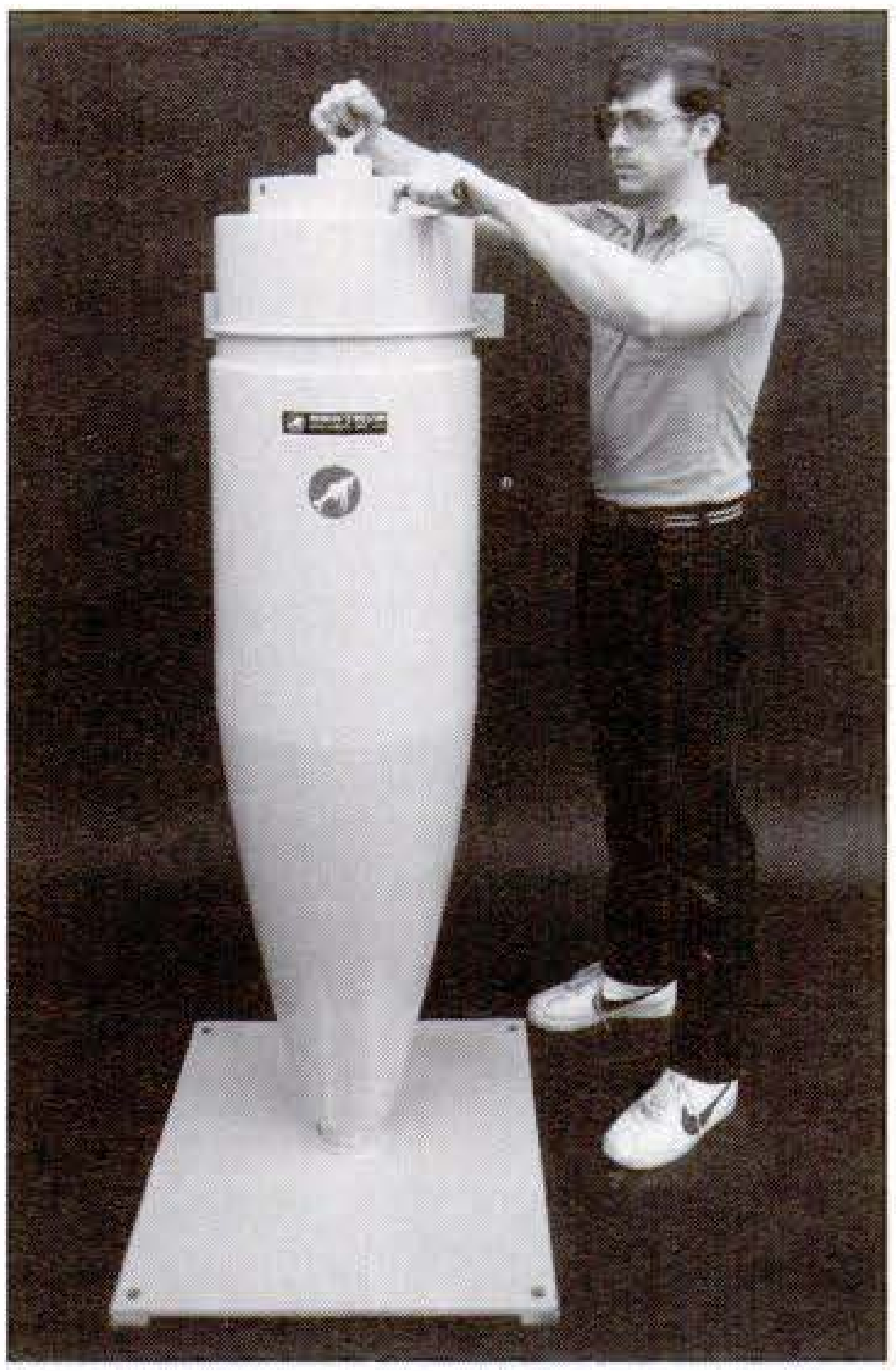
By ARTHUR FISHER



The anatomy lesson

The skull on the screen above is being studied as intensely as Yorick's—by a British medical student. It's part of a new interactive system based on videodisc technology that allows the practitioner-to-be to reinforce the anatomy study traditionally carried out in the dissection room. Called the Anatomy Project, the system lets the user cover specific areas at many levels of detail, and zoom in on or pan around an image. A video paint box can be used to delineate different tissues, highlight systems such as nerve pathways or the blood supply to specific organs, and even simulate the progression of disease. The two British companies that developed the system, Micro Scope and Odeon Projects, estimate that it will take about two years to complete the full set of 20 videodiscs for the whole body.





Shell game

Isaiah's prophecy, "They shall beat their swords into plowshares," has rarely been fulfilled in the 2,700 or so years since he proclaimed it. One striking version is, however, taking place, as pictured in the pair of photos below. In a venture aptly dubbed "Project Plowshare," Benthos, Inc., of North Falmouth, Mass., is converting 16-inch naval gun shells into pressure vessels. The shells, manufactured in 1968 for use aboard the battleship *New Jersey* during the conflict in Vietnam, are made of chromium-manganese steel. Benthos acquired the surplus shells and is turning them into vessels capable of withstanding the high pressures encountered in various scientific and industrial enterprises, from powder metallurgy to oceanography.

Very worrying beads

A company specializing in anti-eavesdropping and other security systems, CCS Communication Control, reports what may be a new low (high?) in the world of bugging and counterbugging. A Saudi businessman came to them complaining of serious security leaks he couldn't account for. Eventually, CCS experts examined his worry beads—ubiquitous in the Middle East. The largest bead contained an ultraminiature radio transmitter, complete with microphone and battery. Thus the gentleman's private conversations could be monitored up to ½ mile away.

Video-display choices

Does the color of the letters on a video-display-terminal (VDT) screen make any difference to a user's comfort and efficiency? What about room lighting?

I was surprised to learn that preliminary results of a study designed to answer these questions indicate that neither has any meaningful effect. Vision researchers at the University of California, Berkeley, observed 35 persons working at VDTs that used either green, amber, or white letters on a dark background, and tested each type of machine under incandescent, regular fluorescent, and high-frequency fluorescent light. The investigators found that VDT users' performance improved by a mere one percent—judged insignificant—when reading

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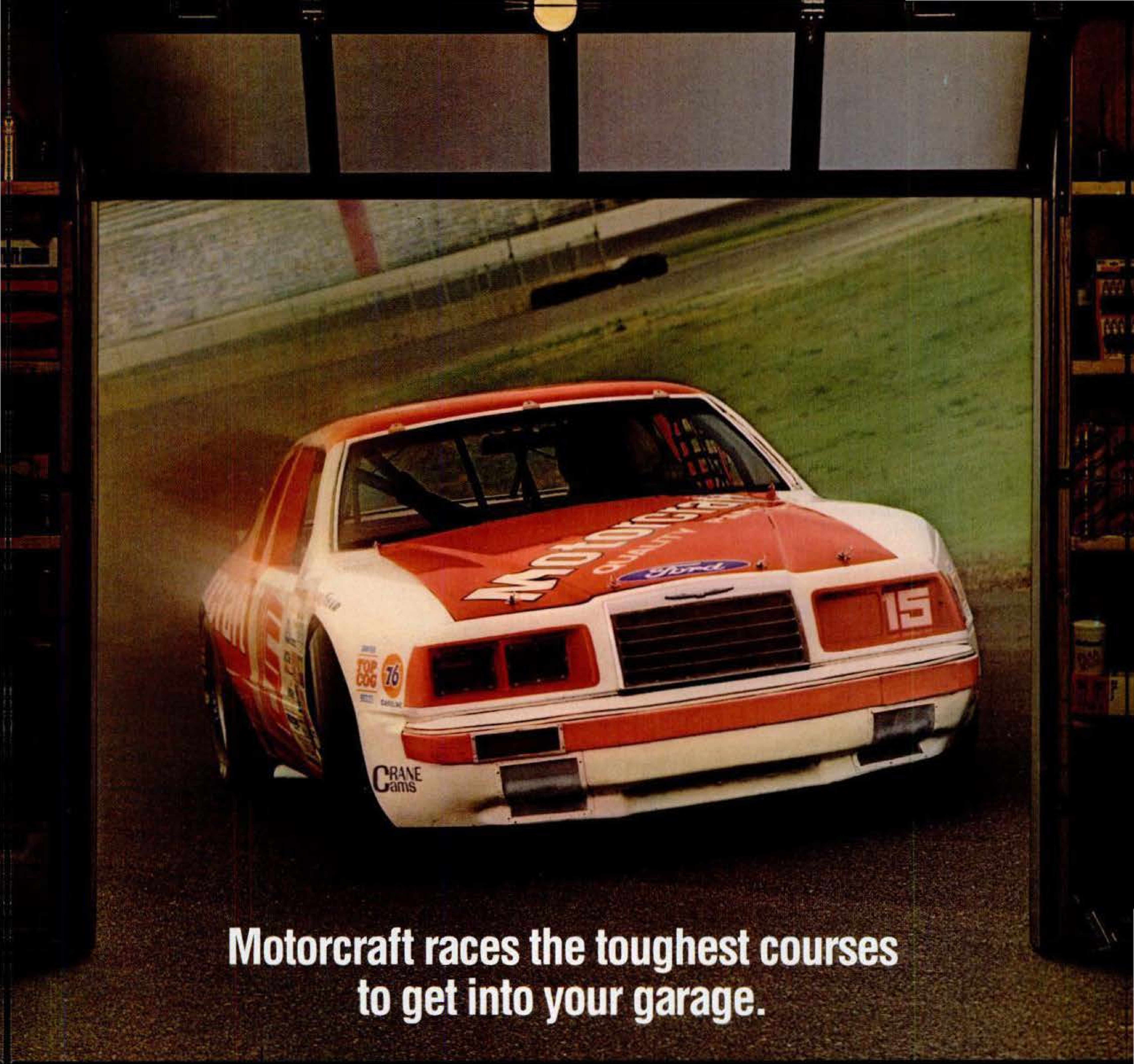
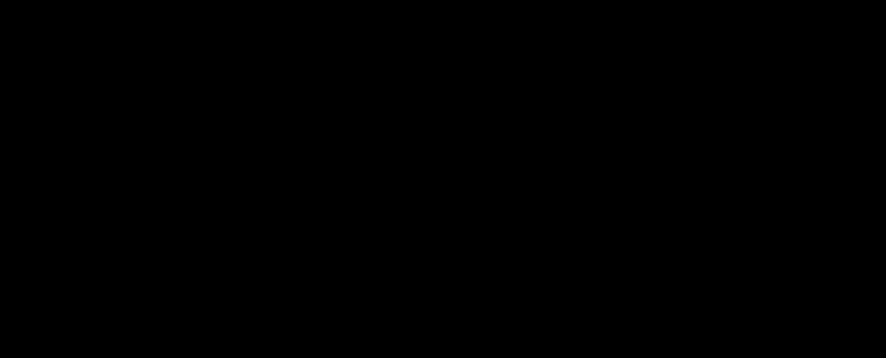

Motorcraft races the toughest courses
to get into your garage.

High-performance racing cars that generate about 600 horsepower demand tough, quality parts. So does your car. And Motorcraft spark plugs, filters, batteries and motor oil deliver top performance, out on the race course or on the highway. Because the technology used to develop Motorcraft racing parts is the same technology used to develop Motorcraft quality parts for your car or truck.

Motorcraft quality parts have been installed as original equipment in more than 35 million Ford, Mercury and Lincoln cars and Ford trucks and are engineered to meet the needs of all vehicle manufacturers. So no matter what kind of car or truck you own, there's only one logical choice. Motorcraft, of course—so you know you're getting reliable original equipment quality replacement parts. Race-proven parts. Trustworthy parts. Motorcraft from Ford. Quality parts for all makes of cars and trucks.

Motorcraft from Ford

EXCEEDS THE NEED


Motorcraft
Tested TOUG
50
Motorcraft
Super Premi
10W-40
Motorcraft
FL-1A
LONG LIFE
OIL FILTER

Buckle up—together we can save lives.

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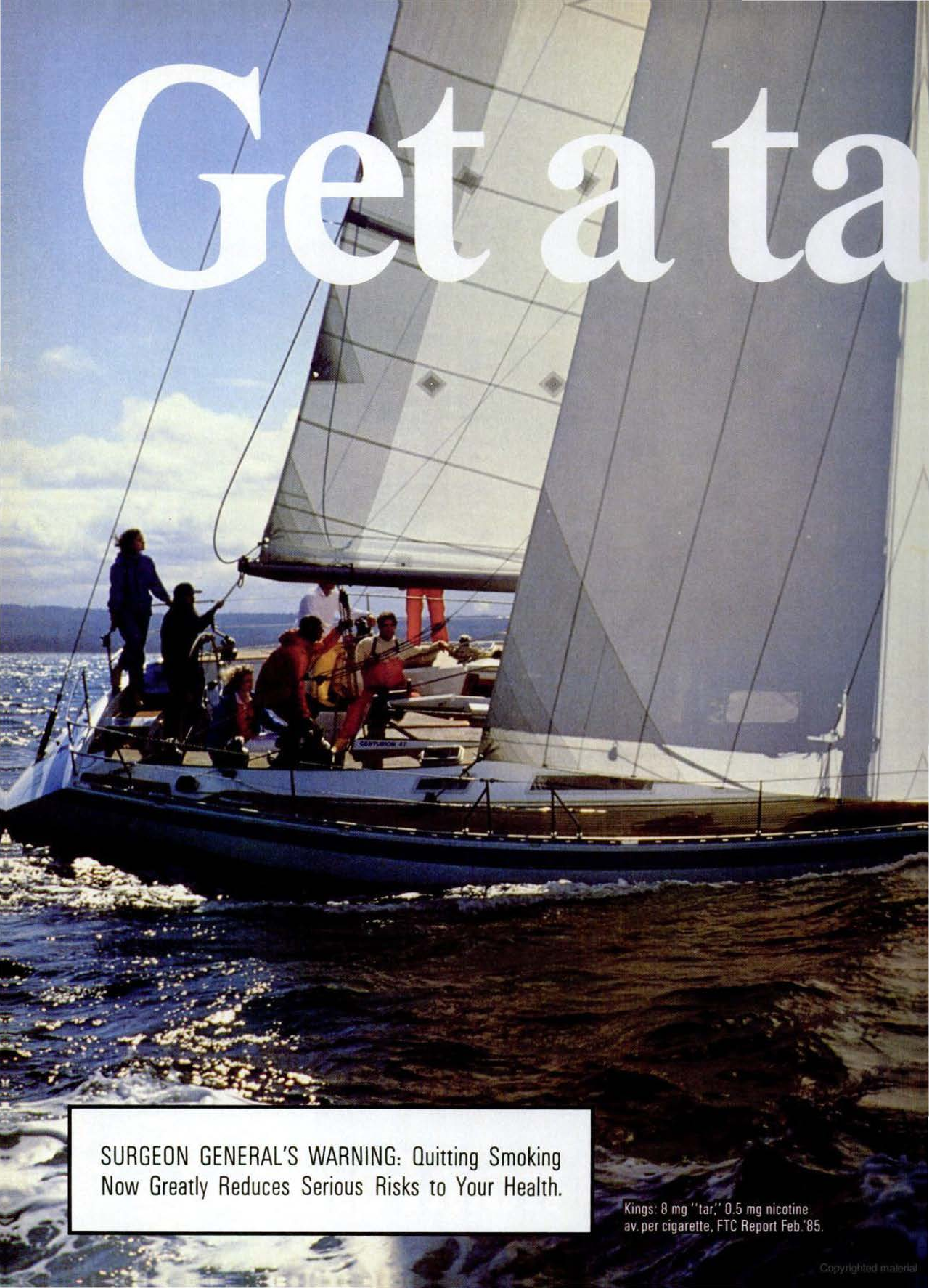

SURGEON GENERAL'S WARNING: Quitting Smoking Now Greatly Reduces Serious Risks to Your Health.

Kings: 8 mg "tar," 0.5 mg nicotine
av. per cigarette, FTC Report Feb.'85.

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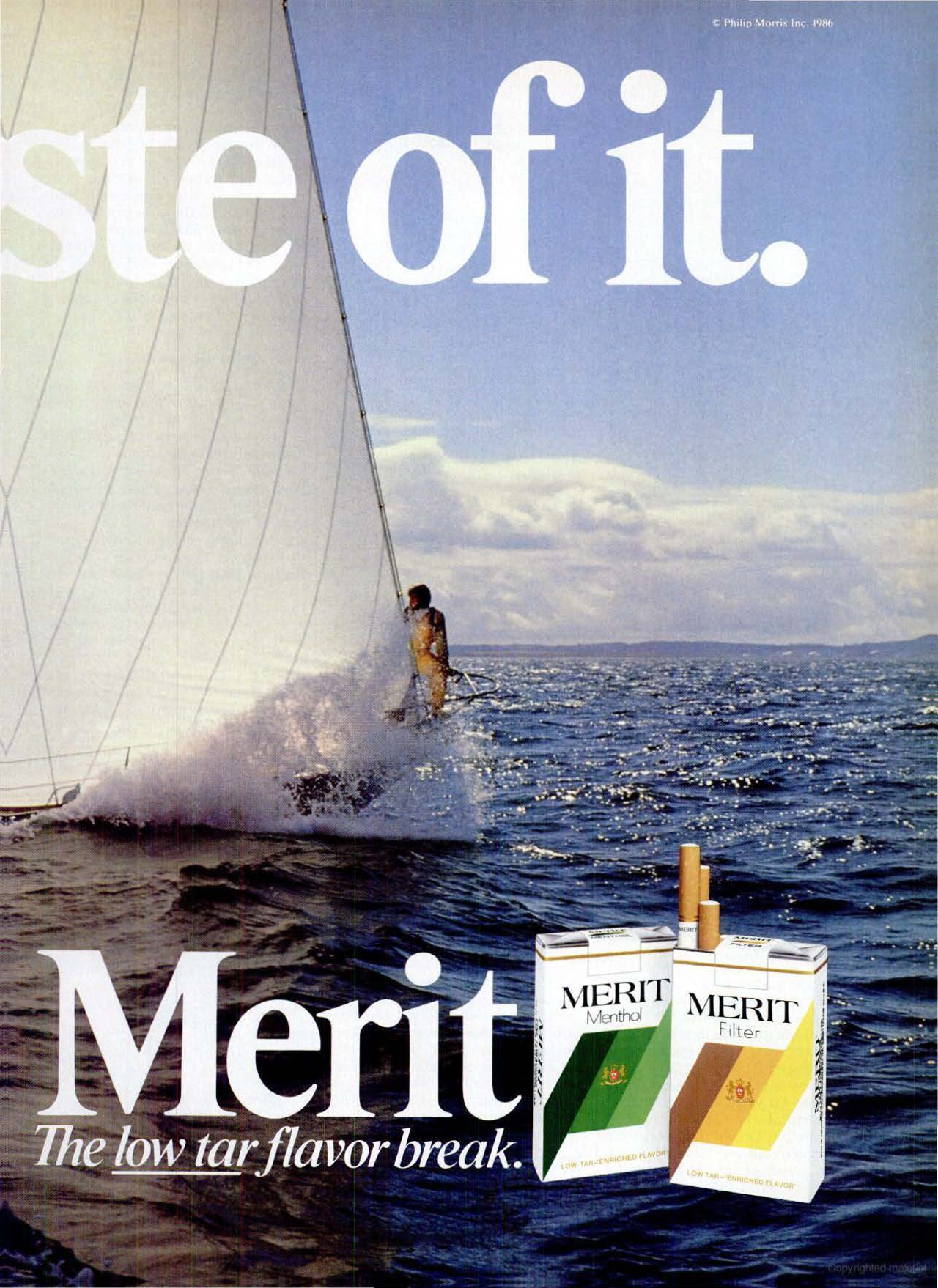
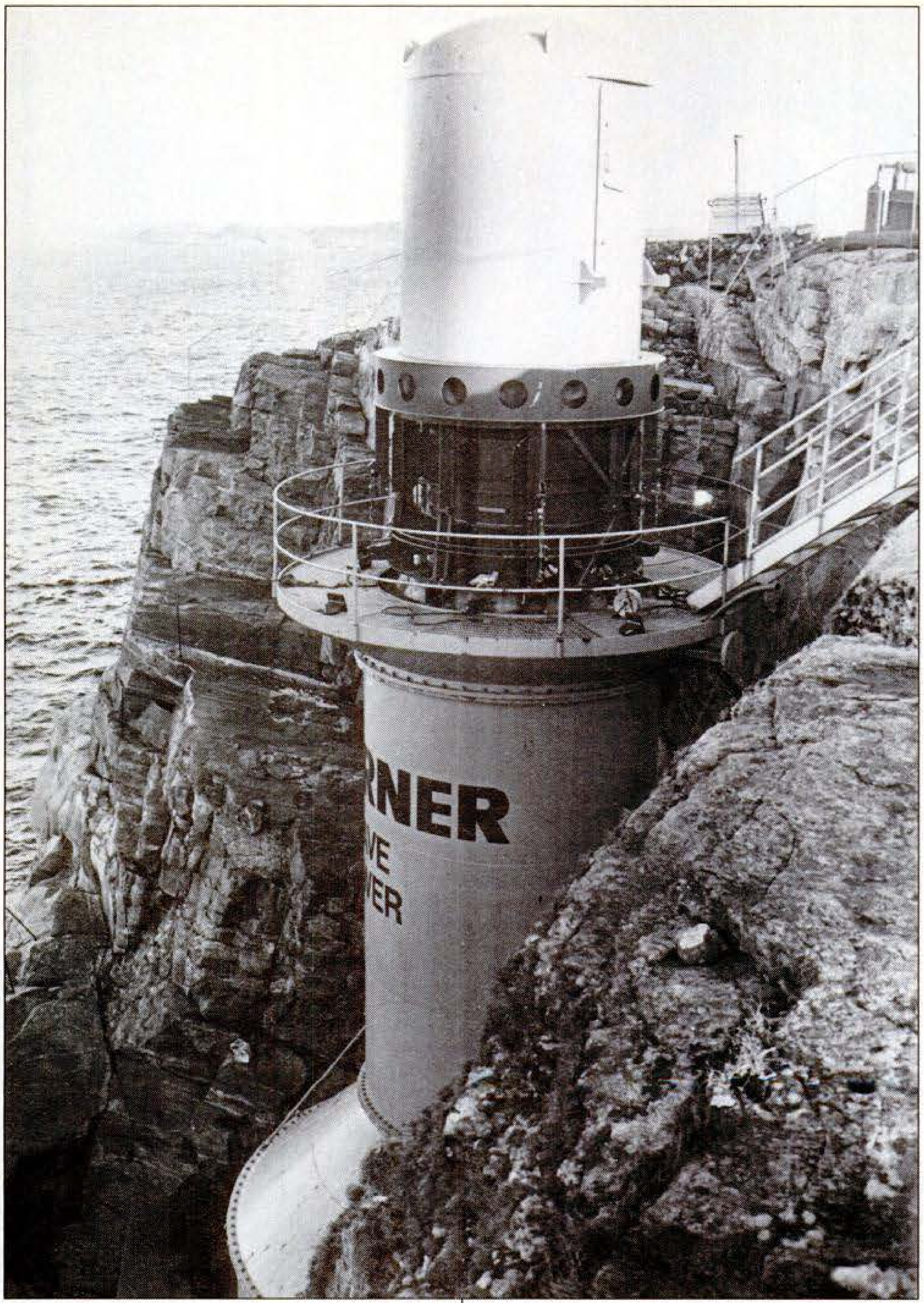


ste of it.
Merit
The low tar flavor break.
MERIT
Menthol
LOW TAR – ENRICHED FLAVOR
MERIT
Filter
LOW TAR – ENRICHED FLAVOR



green letters under incandescent light, compared with any other combination of letter color and ambient lighting.

Norsk wave power

The imposing structure in the photo above is a recently installed wave-power device at Toftestallen, near Bergen, Norway—the first such project in that country. Built by Kvaerner Brug A/S and Norwave A/S, the device represents the culmination of more than 10 years of research and development. Its basic operating principle is simple: Crashing waves at the base compress air and force it into the vertical tower, where the air spins a specially designed turbine called the Pantor. The whirling turbine, in turn, spins an electric generator, and current flows into the grid of the Nord-Hordaland power board. The wave-power station is expected to generate 1.8 gigawatt-hours of energy per year.

Why should Norway, a country blessed with enough hydro power to fulfill 100 percent of its needs, invest in wave power? Because the most efficient and economical hydro schemes have already been developed. Therefore, as energy needs expand, opening new hydro projects will become ever more expensive. Wave power, on the other hand, should become competitive within 10 years.

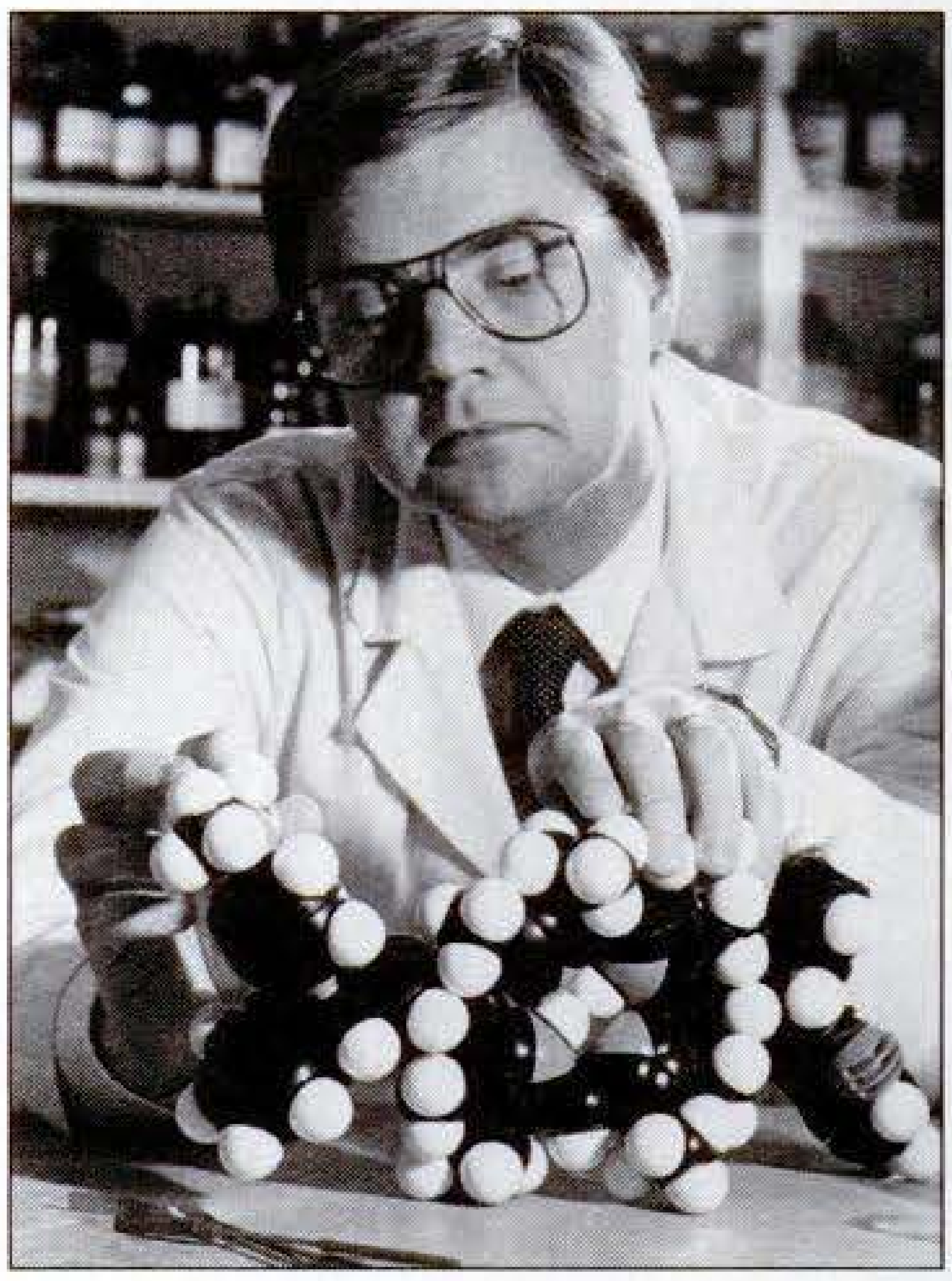
Supercomputing king?

Who's ahead in the race to be firstest with the mostest in the world of supercomputing? Los Alamos National Laboratory claims the crown, at least for the time being, because of its recent acquisition of two CRAY X-MP/48s, commonly held to be reigning champs of the superheavyweight division. The machines can handle 780 million arithmetic operations per second; their memories can store some eight million words; and they use parallel processing. With this much power, says Norman Morse, of the lab's Computing and Communications Division, "In just about a day, our computers can perform more calculations than all of mankind did before 1970."

Key molecule made

A chemist at the Argonne National Laboratory has synthesized a complex organic molecule that mimics a key process of photosynthesis and may lead to future means of producing both food and energy. The chemist, Michael Wasielewski, is assembling a model of the molecule in the photo below. It consists of one molecule each of porphyrin, quinone, and dimethylaniline. Chlorophylls are derivatives of porphyrin, and both they and quinones are found in plant leaves and participate in photosynthesis. Dimethylaniline is a man-made substance that works with porphyrin and quinone to convert solar energy into stored chemical energy. The new molecule converts about 70 percent of the energy in sunlight into chemical energy, and stores it briefly, says Wasielewski.

"The molecule makes it possible to use normal sunlight to drive simple chemical reactions. In the long run, this work could lead to a variety of energy-efficient methods to produce the chemicals that are the basis of a large part of the U.S. economy."



86 FMPM

Shown smaller than actual size. Length approximately 8½

"No one in his right mind would go through all this to make a model car."

Gordon M. Buehrig, designer of the legendary Cord 810, Duesenberg J., Auburn Speedster and, now, Director of Franklin Mint Precision Models.

The 1935 Mercedes 500K Special Roadster.

It sets a standard few, if any, die-cast models have ever approached.

A masterpiece in miniature, it is the first in Franklin Mint's extraordinary new series, The Great Classic Sports Roadsters.

A CUSTOM MODEL OF THIS QUALITY WOULD COST THOUSANDS OF DOLLARS.

Director Gordon Buehrig's determination to create a 1:24 scale model of unparalleled authenticity, detail and craftsmanship required dedication to excellence every step of the way.

An exhaustive search located, from the fewer than 20 originally made, the best of the 500K's still extant today.

The best had recently been voted Best in Show at Concours d'Elegance. From hundreds of photographs and precise measurements of this splendid example, a prototype was built.

From specially made tooling, 111 precision pieces were created, as opposed to the roughly 40 pieces that make up the average model.

Each piece individually inspected.

Each body piece then hand-painted with actual automotive lacquer. The precise Mercedes 500K color.

Each piece then hand-waxed to a high gloss and reinspected. Imagine hand-waxing a model car. The 111 finished pieces finally hand-assembled to form a single car.

Dedication had become compulsion.

ITS OPERATIONAL FEATURES AND INTRICATE DETAILING ARE REMARKABLE.

There is remarkable duplication of the original's extraordinary amount of gleaming chrome trimwork, precisely placed, down to the tiny tips on either of the fender-tred rublines.

Hood, doors and trunk that open and close.

A boot that snaps off.

A convertible top that snaps on.

Full dashboard instrumentation.

Scale-exact tire tread. A "knock-off" hub that covers both spares.

Seats into which just the right amount of "give" has been built.

Engine detailing that includes a Roots-type blower, carburetor and ignition system.

Running gear and suspension on the undercarriage.

Compulsion had become obsession.

And finally, the result is here.

THE MAGNIFICENT MERCEDES IS AVAILABLE ONLY THROUGH THE FRANKLIN MINT.

Crafted and imported exclusively by Franklin Mint Precision Models, the 500K is being offered at the remarkably low price of $90. Upon receiving the order form at right, payment will be billed to you in 3 installments of $30 each.

"We were determined to make the ultimate in die-cast models," said Mr. Buehrig. "We succeeded!"

ORDER FORM

The Mercedes 500 K Special Roadster

Please mail by March 31, 1986

Franklin Mint Precision Models
Franklin Center, Pennsylvania 19091

Please enter my order for The Mercedes 500K Special Roadster, crafted in die-cast metal, to be sent to me fully assembled and ready for display.

I need send no money now. I will be billed for my model in three monthly installments of $30* each, beginning just before the car is ready for shipment.

**Plus my state sales tax and a total of $3. for shipping and handling.*

Signature____________________
ALL ORDERS ARE SUBJECT TO ACCEPTANCE.

Name____________________
PLEASE PRINT CLEARLY

Address____________________

City____________________

State & Zip____________________

53

FRANKLIN MINT PRECISION MODELS

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Automotive Newsfront

Slippery mini

Toyota's AXV experimental vehicle (above) was designed with three goals in mind: ultra-low fuel consumption, attractive styling, and interior comfort.

At the heart of the vehicle's low fuel consumption is a three-cylinder diesel engine. A small turbocharger, which takes advantage of the 1.1-liter engine's short exhaust manifold, increases the tiny diesel's power. Toyota's approach to getting the muscle to the axles is just as unconventional as the power plant: Rather than a power-gobbling automatic, a more efficient continuously variable transmission (CVT) is bolted to the engine.

Keeping the chassis weight in check required innovative material applications. For instance, plastic is used extensively in some new areas, including the steering, windows, chassis, and suspension. Toyota even went so far as to cast the diesel's block in aluminum. The net result is a curb weight of 1,433 pounds, with room to accommodate four adults comfortably.

In the interest of both aesthetics and fuel efficiency, many new aerodynamic features are integrated into the car's design, including thinner flush headlights, perforated flat wheel covers, three-part side mirrors, and even a low-air-resistance cooling system.

Toyota was also interested in providing a more comfortable interior in its test-bed vehicle. To do that, engineers installed a special tilt-away steering wheel, an easy-read speedometer, a centrally located switch cluster, heat-reflective windows, and stepless reclining seats (front and rear). The car's most interesting comfort feature, however, is electronically controlled engine mounts. The mount system sets the spring rate and damping force to "soft" at idle or low speed when fluctuations in torque and engine shake are pronounced. At higher and medium speeds the mounts stiffen.

Supercharged VW

Turbocharging makes weak engines strong, but most of the power is available only at higher engine revs. Supercharging, however, beats both the low-rpm power problem and irritating turbo throttle lag. Supercharging, widely used on racing cars in the 1920s and '30s, has been restricted largely to hot rods because it gulps a lot of fuel. But recently, companies like Lancia, Toyota, and Volkswagen have shown renewed interest in supercharging. Lancia and Toyota's technical investigations have centered primarily on the old Roots-type blower. This supercharger has two paddlelike rotors that intermesh inside a sealed case.

Now Volkswagen has gone even further back in history, to a French design created in 1905. VW calls it the G-charger, and it's already installed on a Europe-only production car. Fitted to the 1.3-liter four (drawing below) in the baby Polo Coupé GT G40, the G-charger boosts power from 55 to 115 hp. VW claims the subcompact does zero to 62 mph in nine seconds and has a top speed of 120 mph. The rotor (inset) has G-shaped spiral

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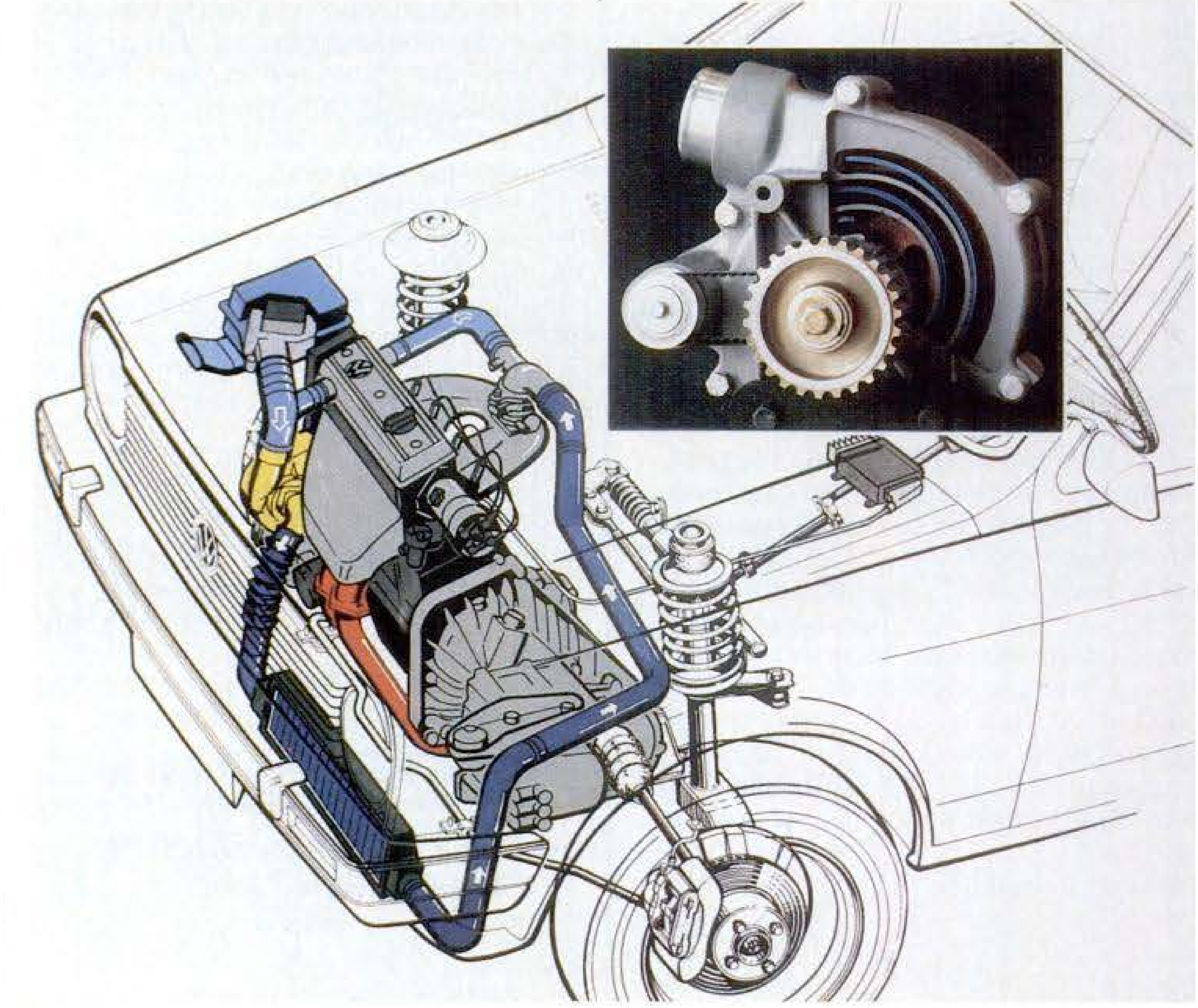


Home Gardening Breakthrough!

At Last! A Rear-Tine Tiller Especially for Small Gardens!

the 3½ HP TROY-BILT® "JUNIOR"

If your garden is 30'x50' or less, here's why it will pay you to get the full story about the Newest, Greatest Breakthrough in rear-tine tillers in over 50 years!...

HALF THE PRICE OF OUR LARGEST MODEL

The BIG JOB tiller...for small, high yield gardens!

- **SAVES YOU MONEY!** Goes for half the price of larger rear-tine tillers—which you don't need for your small-sized garden.
- **SAVES YOUR BACK!** Forget spading and raking! The "JUNIOR" prepares your garden in a fraction of the time!
- **SAVES HAND WEEDING!** It's adjustable to shallow depth perfect for chopping, uprooting and burying weed seeds—killing them. Simply guide the "JUNIOR" up and down the row.
- **SAVES GARDEN SPACE!** Narrow 14" tilling width allows you to plant your rows closer together. Grow more in less space!
- **EASY TO USE!** With its tines in the rear and engine out front, the "JUNIOR" is so well balanced you can handle it with JUST ONE HAND. Won't shake you to pieces like front-end tillers do!
- **EASY TO TURN & MANEUVER!** Because the "JUNIOR" is light and compact (but strong!) you can turn it and maneuver it in tight places with wonderful ease!

There's much more to know about this wonderfully different and better idea in small garden tillers...like how you can use it to build super rich soil, no matter what your soil conditions...or, how it can help you grow two, even three crops of vegetables where you could only grow one before!

So why not mail the coupon TODAY and get all the exciting facts about the amazing TROY-BILT "JUNIOR"... Plus our mid-sized PONY and large garden HORSE Models. We'll include prices, attachments and complete information about our special "OFF-SEASON" Savings discount now in effect!

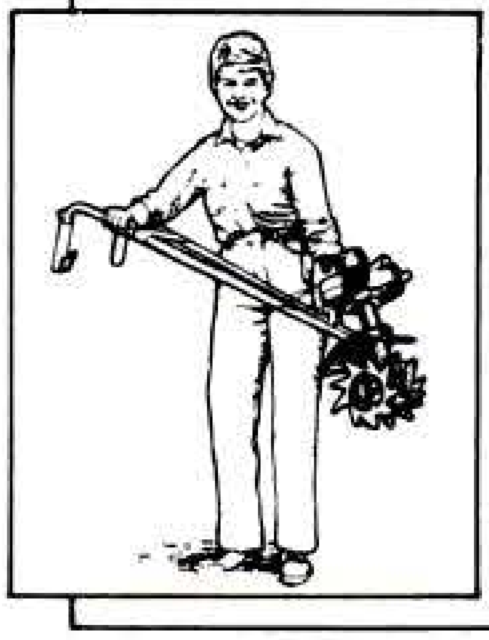
"Grow more in less space!"

"No more hand weeding!"

"Turns on a dime!"

Mail this coupon today!

If you need a machine to do your whole garden...



Please don't buy a "toy tiller"!

Hand-held units with chainsaw engines are not really tillers. They work O.K. as spot cultivators, but are too LIGHT-WEIGHT to till deeply or bust sod. You have to drag them BACKWARDS to make seedbeds. And, they are too UNDER-POWERED to compost effectively.

TROY-BILT® Roto Tiller-Power Composter
Dept. A2544
102nd St. & 9th Ave., Troy, N.Y. 12180

YES! Please send me complete information on the newest JUNIOR and all other TROY-BILT Tiller Models ranging from the 5 HP PONY to the 8 HP "PROFESSIONAL" including details on prices and big "OFF-SEASON Savings now in effect!

Name________________________

Address________________________

City________________________

State____________ **Zip**____________

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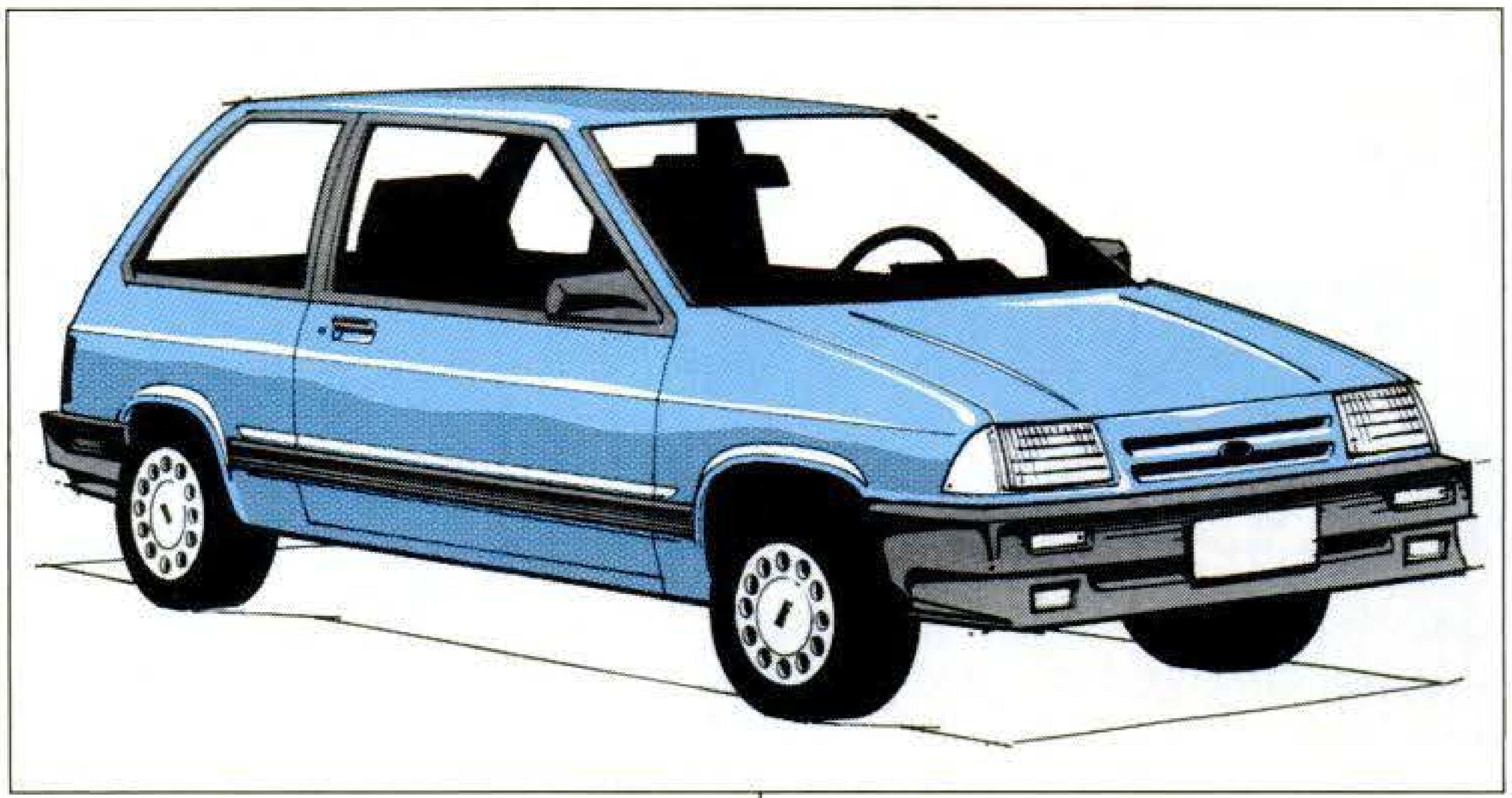


channels interleaved with matching channels in the casing. Compared with the Roots blower, it produces higher efficiency and lower noise, and is smoother running—three of the previously biggest stumbling blocks for superchargers.

Korean Ford

All of the major American car companies are shopping for low-budget models in Korea. Ford is seriously considering importing a Korean mini ["Coming: A New Wave of Under-$5,000 Cars?" PS, Sept. '85] in 1987. More than two feet shorter than Ford's compact Escort, the Festiva (drawing above) will be powered by a 1.3-liter four-cylinder engine. Designed by Ford's affiliate Mazda Corp., Festiva reportedly provides the same interior room as the larger Escort, despite its diminutive size. Future plans for the car call for extra models and a CVT.

$5,000 Subaru

Subaru announced late last year that it will introduce a $4,000 to $5,000 car in January '87. Called the Justy, the front-drive will be powered by a 1.2-liter three-cylinder transverse engine. There will be two models: the DL and GL. The more expensive GL model will sell for between $5,000 and $6,000. Initially available as a front-drive with a five-speed manual, a four-wheel-drive Justy will come later. Insiders say that if production problems can be ironed out, a CVT may be the alternative to shifting.

Plastic coil springs

Plastic coil springs have half the weight of steel, natural damping characteristics, and a good fatigue life, and they reduce road noise. Naturally, they are also corrosion-free. Under development by Britain's National Engineering Laboratory, in Glasgow, Scotland, the springs are made of strips of fiberglass-reinforced epoxy resin (photo below left) pressed in a wavy form. One of the benefits of the new spring technology is the ability to tailor spring rates to the specific application. This is done by changing either the fiber orientation, resin mix, or strip thickness. One British company, Freight Rover, is already mass producing the springs for a light commercial vehicle called the Sherpa.

Future Ford

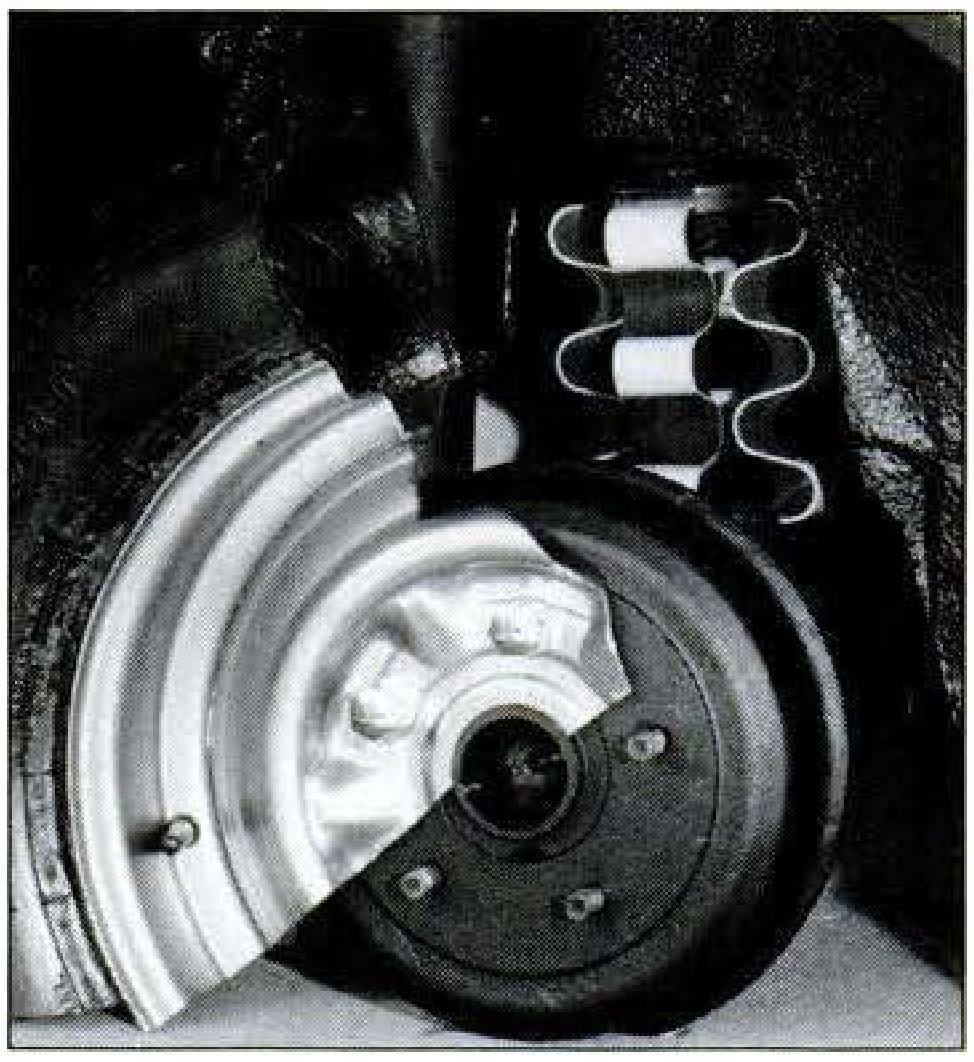
It's what auto makers call a "think tank" car. Ford calls it the T2008 (drawing below). Named to honor the 100th anniversary of the Model T Ford, the T2008 is not a real car. It's a compilation of Ford design, engineering, and manufacturing projections for the 21st century. Some of its advanced features include a satellite telephone hookup, automatic guidance, and even a compressed-air passenger-restraint system to replace seat belts and air bags. But perhaps the T2008's most interesting design feature is modular construction. The car would be built of at least three replaceable modules. Ford's dream car gains credibility when you consider these innovative ideas are from Ford's manufacturing divisions.

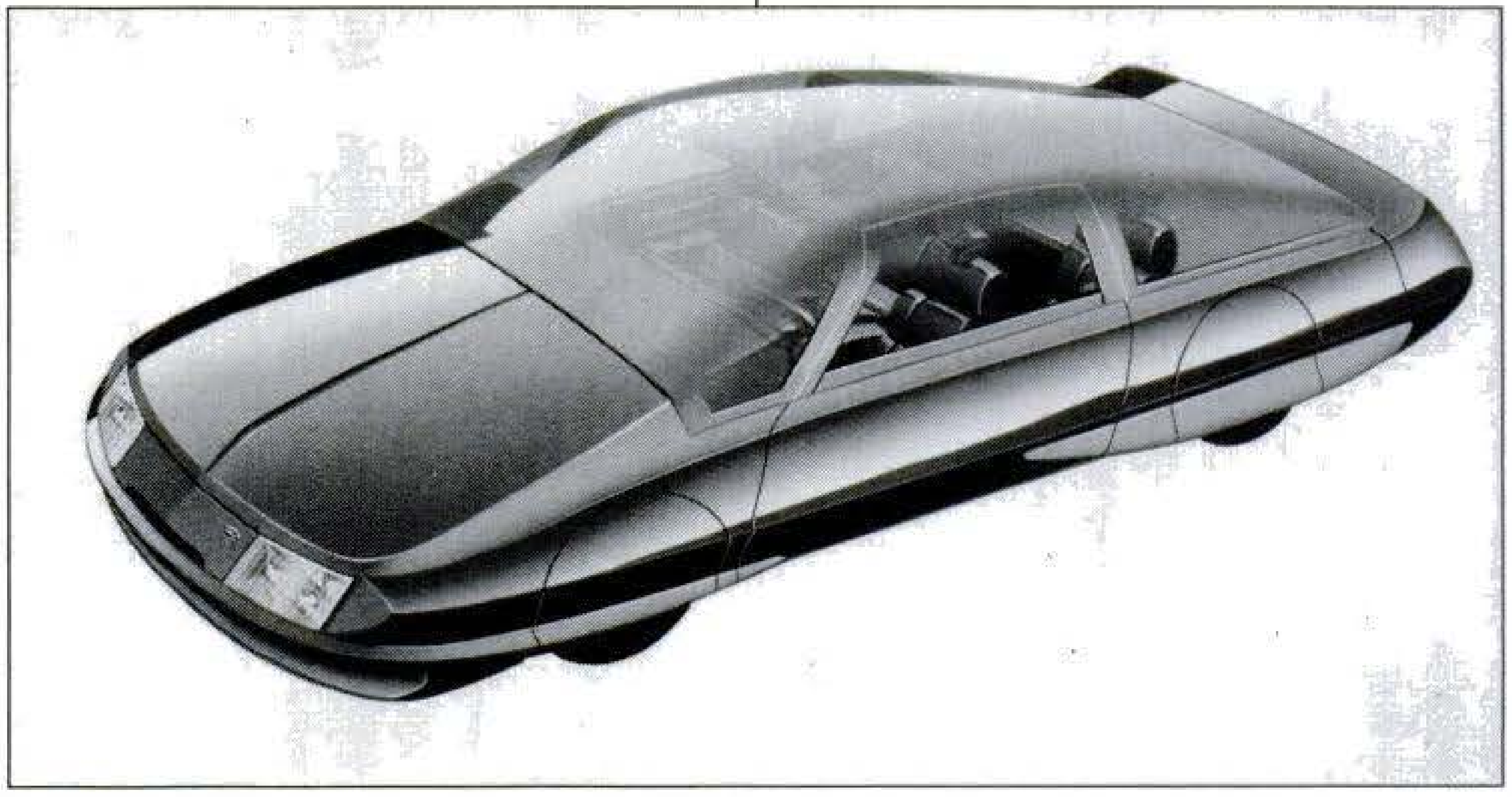
Tempo/Topaz air bags

Starting this month, Ford Motor Co. will offer a driver-side air bag in its four-door Tempo and Topaz models. The system, designed to supplement seat belts, will be priced at $815. The Ford system operates through sensors mounted at the car's nose and on the fire wall that measure changes in velocity and impact forces. The bag deploys in about 1/25 second.

Ford will become the first U.S. maker to offer the option since the General Motors experiment in 1974, '75, and '76. At that time, the GM price was $325. Chrysler presently has no plans to sell a model with an air-bag option. Of course, Mercedes-Benz has been offering an air-bag option since 1984. And this year, air bags come standard on all Mercedes models. According to the company, more than 15,600 air-bag-equipped cars have already been sold.

Contributors: Jack Keebler (New York), Dan McCosh (Detroit), David Scott (Europe).





Small Wonder

It's here, *pocket-size* radar protection.

Imagine a superbly crafted electronic instrument, powerful enough to protect against traffic radar, miniaturized enough to slide into a shirt pocket, beautiful enough to win an international design award.

Small means nearly-invisible protection

That could only be PASSPORT. It has exactly what the discerning driver needs, superheterodyne performance in a package the size of a cassette tape.

This miniaturization is possible only with SMDs (Surface Mounted Devices), micro-electronics common in satellites but unprecedented in radar detectors. It's no surprise that such a superlative design should be greeted by superlatives from the experts.

"In a word, the Passport is a winner," said *Car and Driver.*

The experts report excellent performance. Simply switch PASSPORT on and adjust the volume knob. Upon radar contact, the alert lamp glows and the variable-pulse audio begins a slow warning: "beep" for X band radar, "brap" for K band. Simultaneously a bar graph of Hewlett-Packard LEDs shows radar proximity.

Small means the size of a cassette tape

As you get closer, the pulse quickens and the bar graph lengthens. Should you want to defeat the audible warning during a long radar encounter, a special switch provides silence, yet leaves PASSPORT fully armed for the next encounter. A photocell adjusts alert lamp brightness to the light level in your car. PASSPORT was designed for your protection *and* your convenience.

In PASSPORT, 102 SMDs (right) do the work of ordinary transistors, resistors and capacitors.

PASSPORT comes with a leather case and travels like a pro, in your briefcase or in your pocket—to the job for trips in the company car, on airplanes for use in far-away rentals. Just install on dashtop or visor, then plug into the lighter. PASSPORT keeps such a low profile. It can be on duty without anyone noticing.

Small means an easy fit in the briefcase

One more PASSPORT convenience—call us direct. It's toll free. We make PASSPORT in our own factory and we'll be happy to answer any questions you may have. If you decide to buy, we'll ship your PASSPORT within 24 hours by UPS, and we'll pay the shipping. For an extra $6.00, Federal Express guarantees 48-hour delivery.

If you're not satisfied within 30 days, return PASSPORT. We'll refund your purchase and your return shipping costs. There are no hidden charges.

Isn't it time for a PASSPORT of your own?

$295 (OH res. add $16.23 tax)
Slightly higher in Canada

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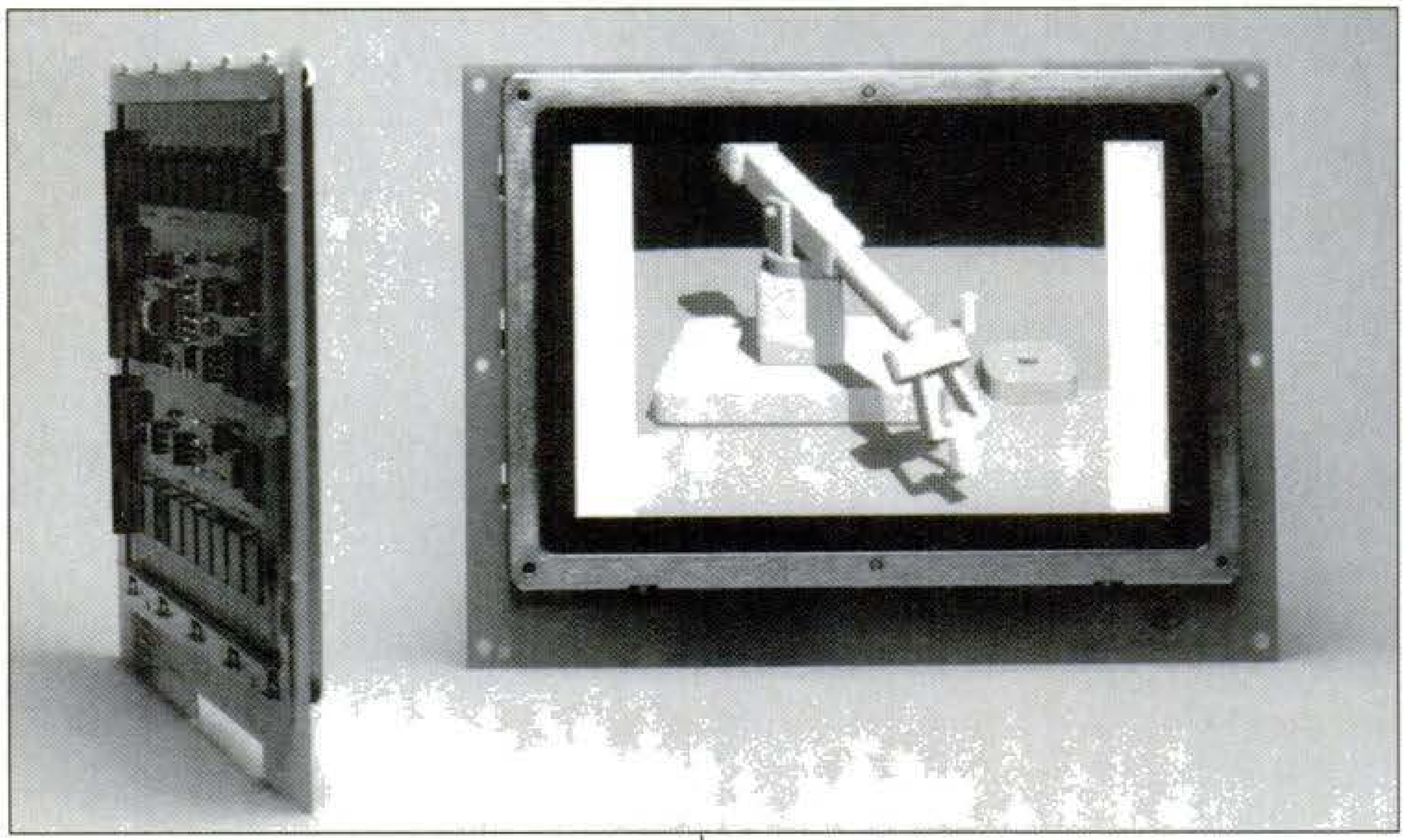
PASSPORT®
RADAR·RECEIVER

Call Toll Free 800-543-1608
Cincinnati Microwave
Department 100-016-C15
One Microwave Plaza
Cincinnati, Ohio 45296-0100

Electronics Newsfront

By WILLIAM J. HAWKINS



Goodbye, CRT and LCD?

It's the thinnest electroluminescent display available: The EL8358 (shown above) is 0.55 inch thick. It has a resolution designed specifically for MS-DOS computers (640 by 200 pixels, 80 columns). The display, made by Planar Systems (1400 N.W. Compton Dr., Beaverton, Ore. 97006), has been bought by a major computer maker for use as an alternative monitor. The electroluminescent display will replace a CRT. Because of the display's low weight (16 ounces) and low voltage requirement (12 volts), it is also a strong contender for all future portable computers, replacing the hard-to-read LCD displays now in use.

Amorphous computer

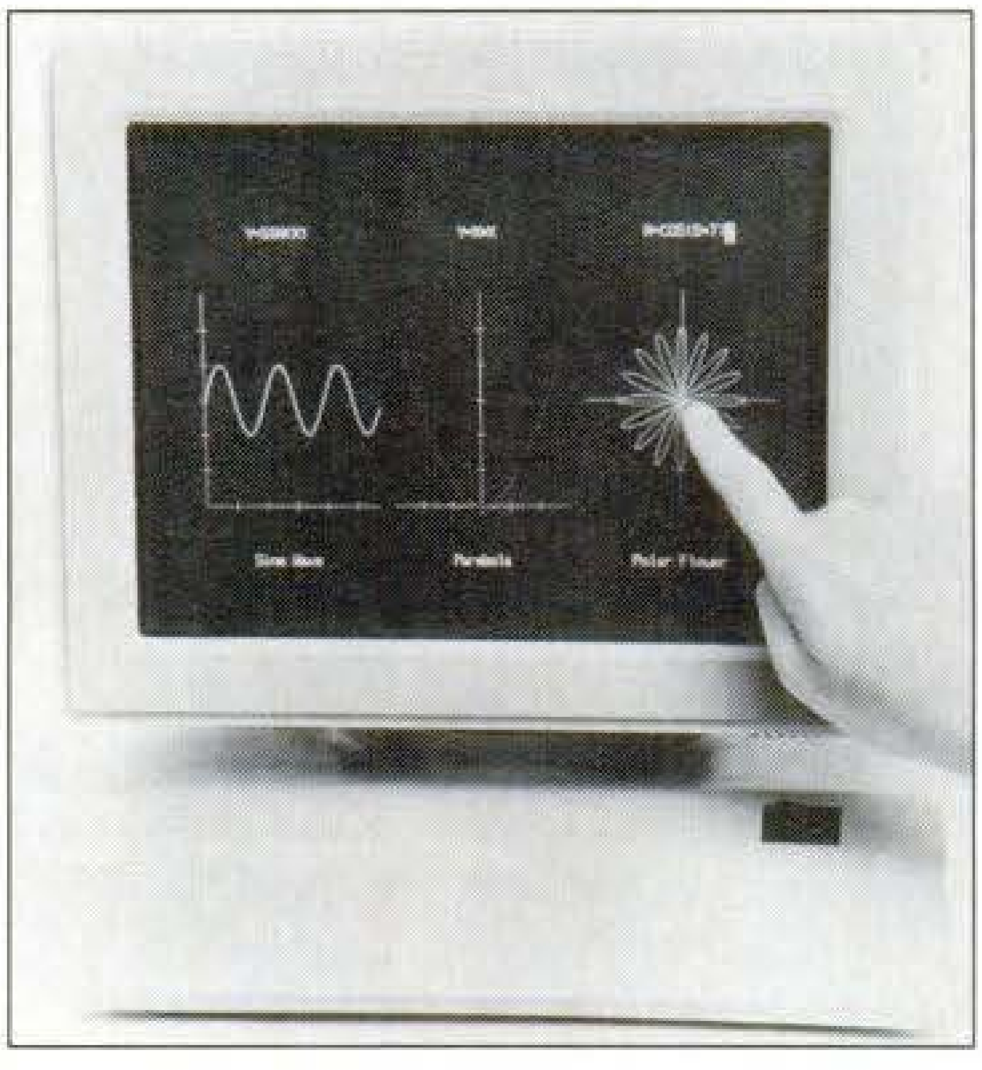
Energy Conversion Devices (1675 W. Maple Rd., Troy, Mich. 48084) has begun work on a computer that uses amorphous materials. (These materials are used to create extremely large semiconductor chips.) According to the company, the all-thin-film amorphous computer—the size of an 8½-by-11-inch sheet of paper—could replace a roomful of present computers. And one cubic foot of its three-dimensional amorphous memory holds as much data as an entire acre of disk drives.

3D touch screen

Put your finger on a touch screen, and the location of your fingertip is sent to a computer as two-dimensional horizontal and vertical coordinates. Often the location is determined by infrared light beams and sensors scattered along the screen's perimeter. But a new touch screen (photo below) from Zenith (1000 Milwaukee Ave., Glenview, Ill. 60025) detects sound to determine a third dimension: pressure. Two piezoelectric elements create the sounds; acoustic reflector strips send them across the tube face, creating a matrix of up to 50 touch points.

Pattern reader

Called Softstrip, it's a graphic pattern that can be printed directly on paper. The pattern contains data—which can represent programs, graphics, and sound—in a highly compressed format. When you drag a special electro-optical scanner across it, as in the photo below, the encoded information is sent to a personal computer for use. Its makers, Eastman Kodak Co. (343 State St., Rochester, N.Y. 14650) and Cauzin Systems (Waterbury, Conn.), intend to license the technology to software publishers as a new way to sell programming material.



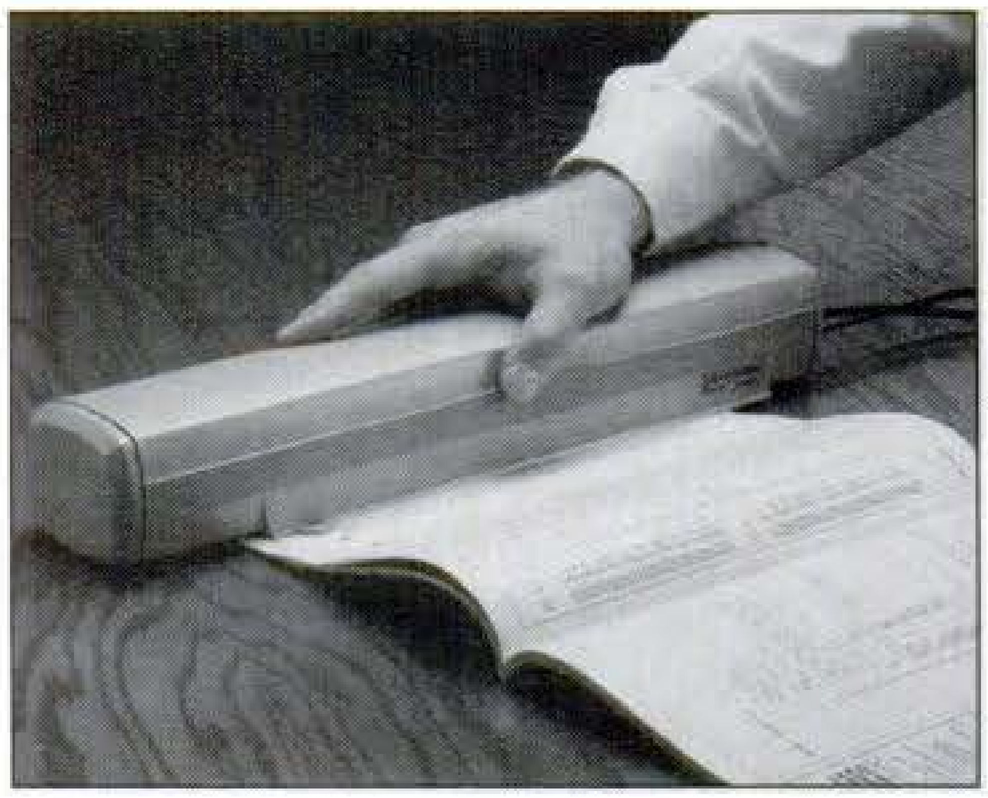
Speak—normally—to me

"This... document... describes... the ... use... of... voice... recognition... products."

James Baker, chairman of Dragon Systems (55 Chapel St., Newton, Mass. 02158), spoke slowly and deliberately into the microphone. As he said each word, it appeared on the screen of the IBM AT in front of me.

"I'm speaking slowly because the system is set to take the maximum amount of time [1.5 seconds] to search for the correct word," he told me. "Actually, the computer is ninety-eight-percent certain that it knows the word before I finish speaking it."

Voice recognition is not new to computers. Texas Instruments, ITT, and IBM offer add-on circuit boards that give computers a vocabulary of up to 200 words. But Baker called me to his New York hotel suite to demonstrate a new program that allows the computer to recognize any one of 2,000 words—as they are being spoken.



"Conventional voice-recognition systems work on a single word at a time," said Baker. "There's a definite start and stop point for each one. That's slow, and it requires the user to have an unnatural, staccato voice. We use continuous-speech recognition."

To a computer programmed with Baker's voice-recognition system, there are no words, just continuous sounds—from background room noise to human utterances. The program uses a special algorithm to break the sounds into words contained in a dictionary. "By analyzing sounds continuously," said Baker, "the software can understand normal speech." That could result in devices like the long-sought electronic typewriter that takes your dictation.

When will it be available, and how much will it cost? Baker stresses that he is in research, not manufacturing. "We're demonstrating a new technique here," he said, "not a new product." But he's also in business: Dragon hopes to license the software to its clients, IBM and Apricot.

Quick looks

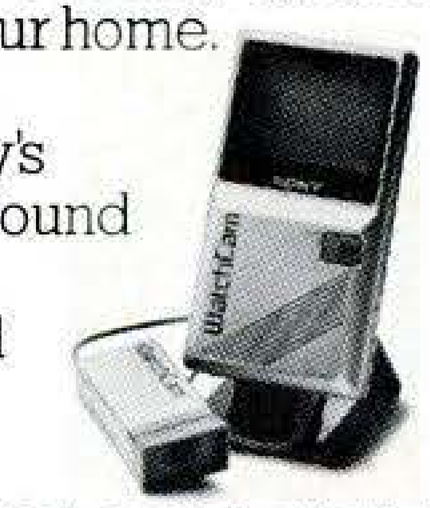
- Porta-Mount is a five-foot satellite dish that folds down when not in use. That, claims the maker, Channel Master (Box 1416, Smithfield, N.C. 27577), makes it practical for apartment residents and vacationers.
- PC Scheme is a new form of the LISP programming language, which is used to develop artificial intelligence on PC-compatible computers. Available from Texas Instruments (Box 2909, Austin, Texas 78769), it's $95.
- A new 40-inch rear-projection monitor/TV from Pioneer Video (200 W. Grand Ave., Montvale, N.J. 07645) uses a 160-mm lens system to produce a picture with high resolution (450 lines) and brightness (300 footlamberts). Both specifications are better than conventional direct-view TV sets. Price: $3,500. Or, for the same price, you can buy the new 6.5-foot Novabeam 100 monitor/projector from Kloss Video Corp. (145 Sidney St., Cambridge, Mass. 02139). It uses the Faroudja image-processing system, which is claimed to restore the detail lost in recordings or broadcasts. The projector has a nine-megahertz bandwidth capability, and it accepts an RGB input.
- Citicorp and Panasonic Industrial Co. have created the Pocket Terminal: The one-by-three-by-5.25-inch display terminal plugs into any modular phone jack to let you check account balances, transfer money, or pay credit cards.
- Making a computer understand plain English has for years been the dream of artificial-intelligence software designers. And now, after some 30 years of work, there are some results. For example, Lotus Development Corp. (161 First St., Cambridge, Mass. 02142) will incorporate a program called HAL (named in honor of the computer in the movie *2001: A Space Odyssey*) into many of its future programs. Using HAL and a 2,000-word dictionary, programs like Lotus 1-2-3 will understand spread-sheet vernacular: Enter a plain-English command on the keyboard, such as "What is the average cost per day?" and the answer is instantly computed. Similarly, a data-base program called Paradox, $695 from Ansa Software (1301 Shoreway Rd., Belmont, Calif. 94022), accepts examples of the type of information you'd like to find—then uses AI to find it. The program requires an IBM PC (or compatible computer), two disk drives, and 512K of memory.

Take aspirin, sing to me in the morning

Speaker manufacturers never cease trying to create the "ultimate" acoustic transducer, but a woman described in the *New England Journal of Medicine* may have them all beat: For three weeks she heard music—songs from the 1930s and '40s—without the aid of any electronic device. According to her doctor, the music was the result of a chemical imbalance caused by large doses of aspirin (12 tablets) she took daily to help combat arthritis. If you're a music lover, this is certainly a rare but positive advantage of aspirin. Tylenol backers, however, are swift to point out that the songfest was not in stereo.

Now you can see who's there...

without leaving your chair.



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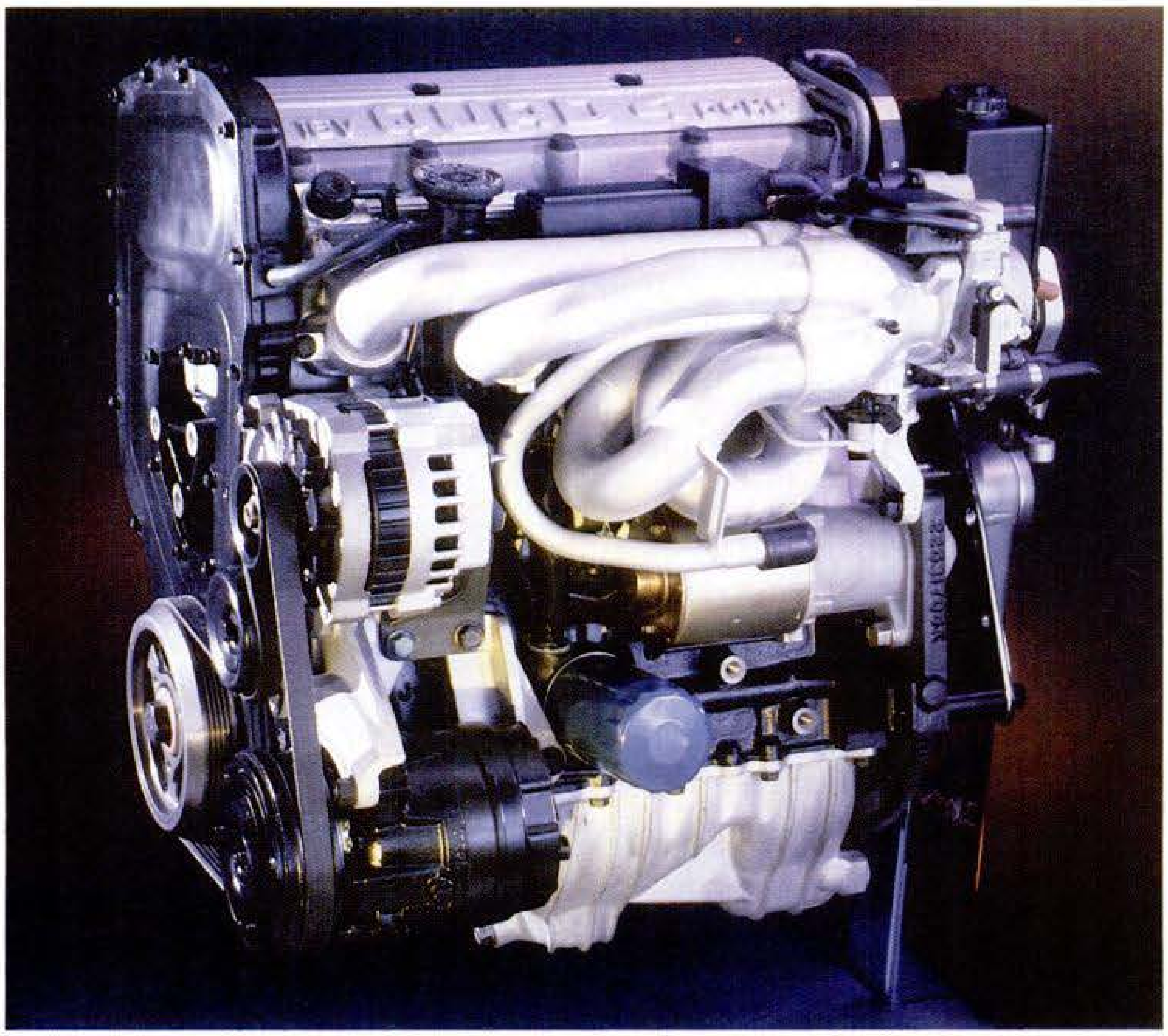
16 valves from GM

The 2.3-liter four-cylinder Quad 4 will use four valves per cylinder, tuned manifolds, electronic fuel injection, and distributorless ignition to produce 150 horsepower. General Motors will offer the engine in several models starting in 1987.



By DAN McCOSH

As one of the greatest manufacturers and promoters of the modern V8, General Motors Corp. has rarely thrown the full weight of its engineering resources behind the development of a four-cylinder engine. Faced with an energy crisis or a boom in import sales, GM might abduct a four-banger design from its operations in Brazil or Europe—and once it even sliced a V8 in half lengthwise. But few small GM engines have ever come from a clean drawing board.

This explains some of the anxiety of the handful of engineers milling in the cold rain last December as they watched two prototype Oldsmobile Calais sedans hydroplaning across the flooded pavement of the GM test track in Mesa, Ariz.

The nervous glances seemed appropriate. The cars trailing the rooster tails of spray were powered by preproduction prototypes of the Quad 4—a 16-valve 2.3-liter four-cylinder

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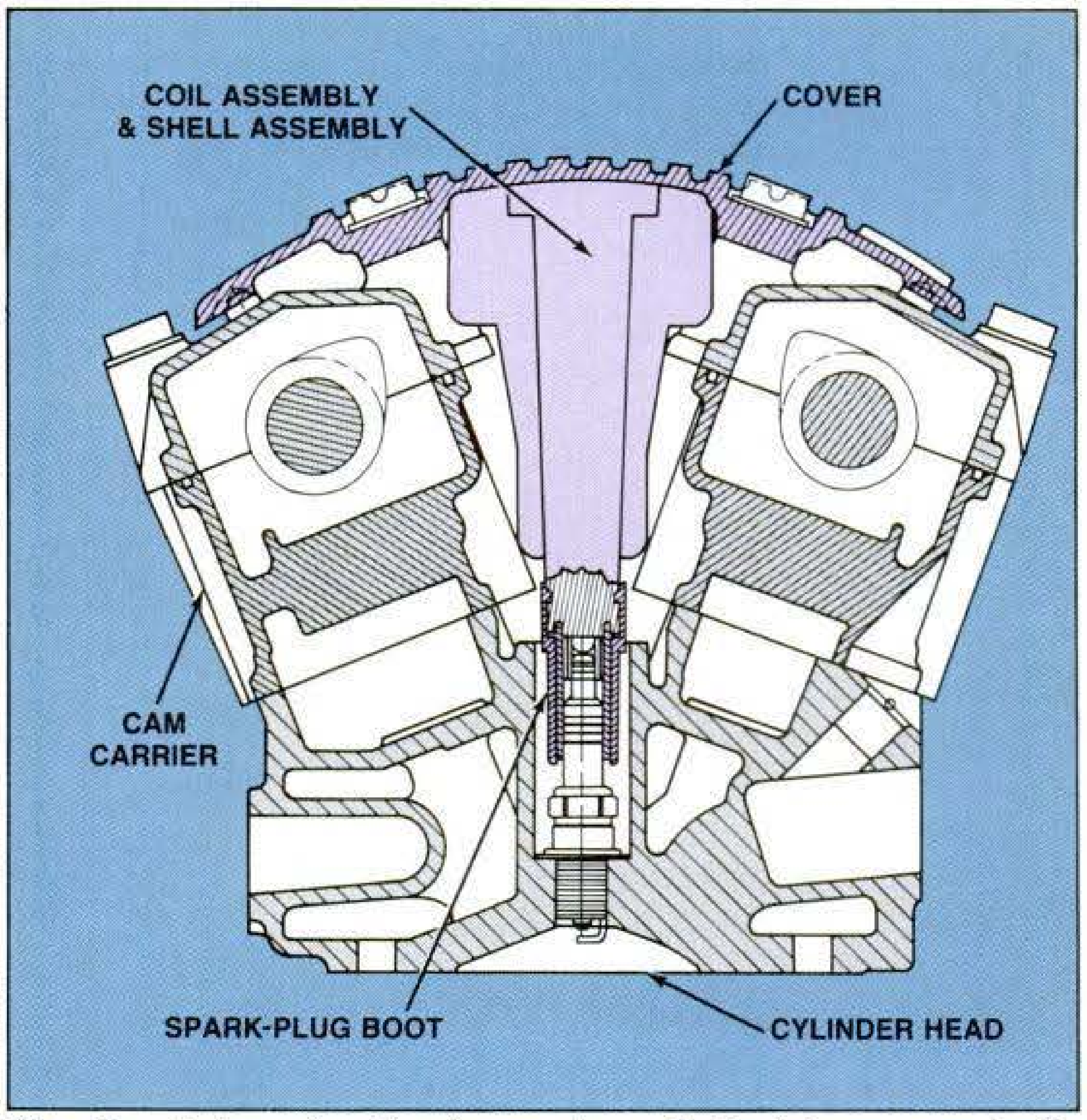
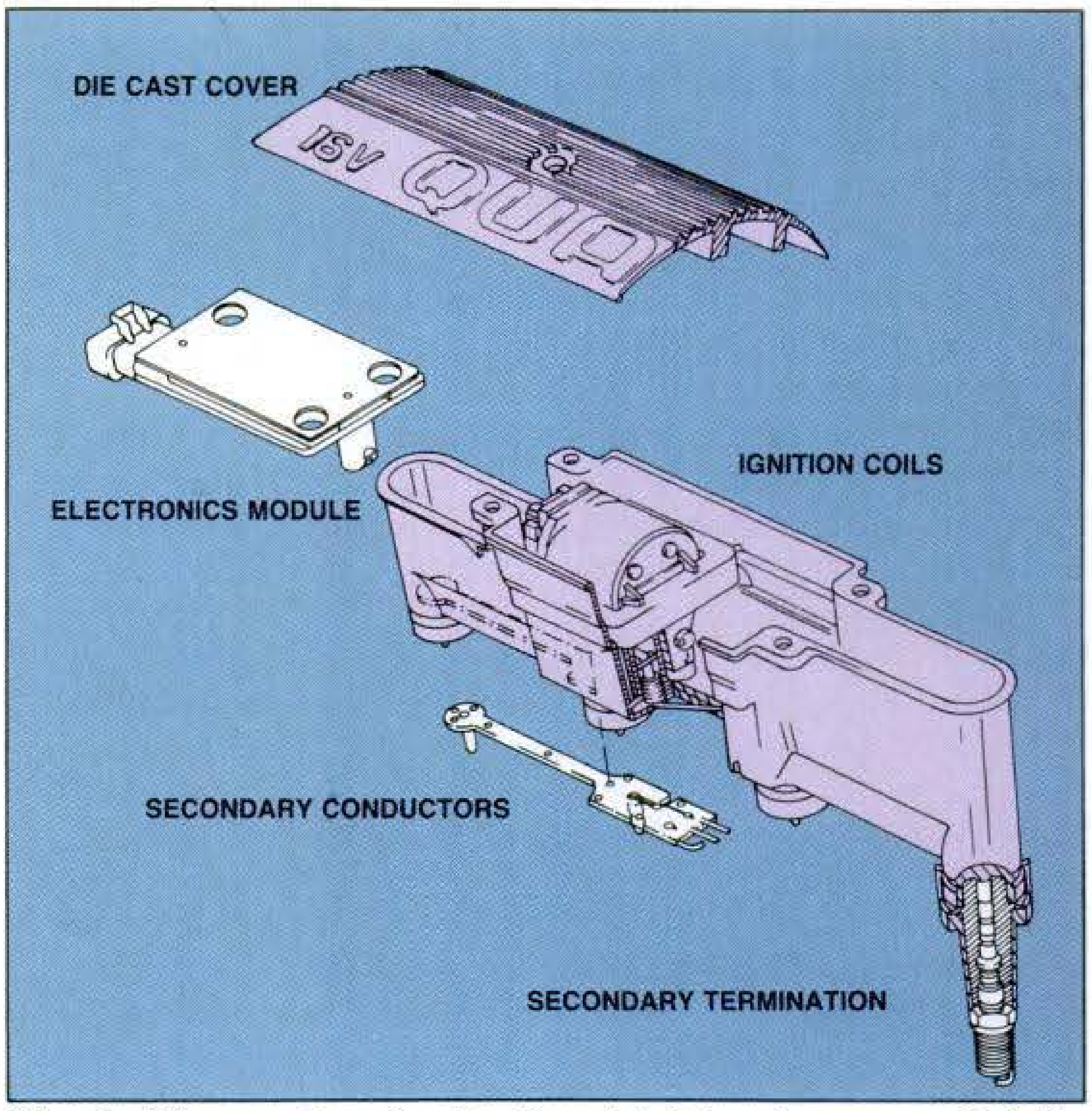


The Quad 4 engine (top) uses two chain-driven camshafts to operate two intake and exhaust valves for each cylinder. The spark plug is located at the top of each combustion chamber and is connected directly to one of the two coils in the direct-ignition system (above).



The ignition system for the Quad 4 (above) uses no distributor. High-output coils mounted on the cylinder head connect directly to the spark plugs, while the engine-control computer receives timing information from the crankshaft. A distinctive aluminum cover protects the ignition system.

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power plant developed by GM's Oldsmobile Division. Olds chief engineer, Ted Louckes, standing beside me in the rain at the test track, said with some excitement, "This is the first all-new engine from Olds since the 1948 Rocket V8."

The new Olds engine is a turning point in GM's small-engine philosophy. It's the company's first attempt to build a high-tech four-cylinder engine —one designed to equal the power and smoothness of a V6 or V8, but with better fuel efficiency.

The engine won't be available in showrooms for more than a year, with the first installation planned for a 1987½ Calais. But GM is already according the Quad 4 engine program some of the reverence normally reserved for such landmarks as the 1948 high-compression Kettering V8 and the venerable 1955 small-block Chevy V8. The company is proclaiming the Quad 4 a watershed in its thinking about where tomorrow's horsepower will be coming from. "This engine uses the technology of the world's best engine builders," Louckes says.

The Quad 4 will compete head-on with Porsche, Saab, Toyota, and Mercedes, who already produce 16-valve four-cylinder engines for passenger-car use. Oldsmobile's new engine uses two intake and two exhaust valves per cylinder, as well as tuned intake and exhaust manifolds for improved breathing. Electronic fuel injection and direct ignition, which uses no distributor, help boost output to 150 horsepower. That's a substantial increase from GM's current 2.5-liter four, which produces 88 hp and 132 foot-pounds of torque.

My test drive on the rainy track at Mesa didn't allow any meaningful check of the 8.4-second zero-to-60 time that Oldsmobile claimed for the Calais with the Quad 4 and a manual transmission. But a hand-held stopwatch did reveal that a Calais with this hot new four-cylinder would walk away from the current 2.5-liter Calais. And in an impromptu drag race with a Calais equipped with the current three-liter V6, the car with the Quad 4 was two car lengths ahead at 60 mph.

To complete the unfair comparison, one prototype Calais was equipped with a new Getrag five-speed gearbox, a smooth-shifting transmission that will go into production for the 1987 model year. The Getrag is GM's latest answer to complaints about the rough shifting in its present generation of manual transmissions.

More important than the raw power of the engine was its smoothness, even in the test-bed cars I drove. Only a trace of high-frequency vibration was detectable at any engine speed up to the 7,000-rpm red line. Gone was the familiar harmonic rumble that creeps around the tuned engine mounts of the 2.5-liter GM four.

GM engineers told me that the basic 150-hp version of the Quad 4 will be followed by a 180-hp high-output version. That would actually match the horsepower—though not the 245 foot-pounds of torque—of the five-liter V8 in the current Oldsmobile 442. And in turbocharged form, the Quad 4 promises some 250 hp. That compares with 220 hp for the new 2.5-liter Porsche 944 turbo, and 200 hp for the Buick 3.8-liter V6 turbo.

The Quad 4 has been designed to take advantage of the benefits of four-cylinder designs while avoiding some of the pitfalls. At a given displacement, four-cylinder configurations offer low internal friction. An in-line four also makes for straightforward valve actuation and manifolding, which are particularly important when using four valves per cylinder.

But these advantages are offset by high piston mass and balance problems—particularly up-and-down shaking forces—inherent in an in-line four. These balance problems tend to be exaggerated in four-cylinder engines of more than two liters, one reason why Japanese and European manufacturers favor smaller-displacement engines. That's also why counterrotating balance shafts used to dampen shaking forces are becoming more popular on large-displacement fours.

> “*In some ways, the engine is as remarkable for what's left out as for what's included*”

Oldsmobile engineers said they concentrated on smoothing the shaking forces by reducing piston mass. The thin-wall aluminum pistons and connecting rods that have resulted are about 40 percent lighter than those used on the 2.5-liter four-cylinder. The reason? A new machining process allows GM to make thinner pistons and connecting rods than ever before. "Before, we had to design extra weight in to meet the stresses of manufacturing—not just the strength the piston needed to work in the engine," said Marv Thompson, an Olds development engineer. "We also use an eight-counterweight crankshaft, rather than the four weights used on the 2.5, to cut bearing wear," Thompson added.

Louckes told me that Olds wanted to avoid the small horsepower loss due to the balance shafts, and claimed that even without the shafts, the Quad 4 has less shaking forces than the smooth-running 1.8-liter Honda engine.

The Quad 4 generates its power by adopting techniques familiar on racing engines. Although nothing in the design of the engine is completely new, much of the technology is only beginning to enter volume production.

A tuned intake manifold feeds air to the cylinders, and fuel is supplied by individual injectors controlled by a new-generation engine-control computer.

Olds engineers said the cylinder head for the Quad 4 was inspired by that of the Cosworth Vega, a two-liter 16-valve version of the Vega four that GM sold briefly. One prototype of the Quad 4 even sported a Cosworth-style head machined from solid billets of aluminum, but production heads will be die cast. A bundled 4-2-1 tuned exhaust, which feeds spent gases from four, to two, to one pipe, completes the picture.

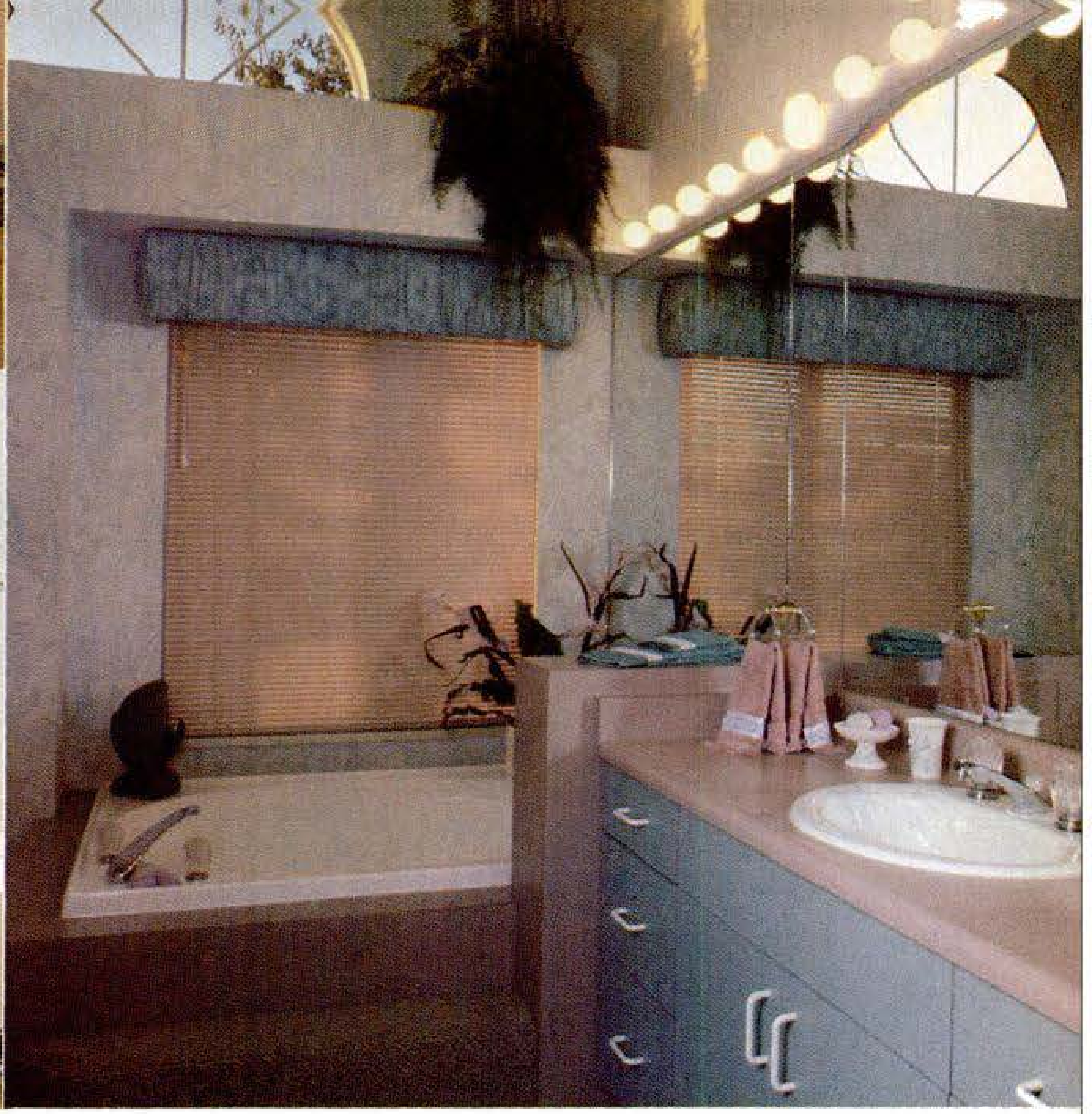
The computer-controlled ignition system is similar to one recently adopted by Buick. It works without a distributor, receiving timing information from the crankshaft. Two high-voltage coils mounted on top of the cylinder head fire the spark plugs directly, without ignition wires.

In some ways, the engine is as remarkable for what's left out as for what's included. Not only does it lack a distributor and balance shafts, the Quad 4 also does without an air pump and exhaust-gas recirculation system. These exhaust-emissions devices are fast becoming obsolete as computer-controlled fuel injection improves the precision of the air-fuel mix.

Finally, the Quad 4 hints at other trends for future engine development at GM. "We're looking at lean burn," says Arthur Frelund the Olds engineer who supervised the development of electronic controls for the Quad 4. "We would need to change heads—probably go to two spark plugs. We've left room in the design for the changes."

The high-voltage circuitry in the Quad 4 ignition system is a necessary building block for a future lean-burn engine, which would use two-platinum-tipped spark plugs per cylinder. There is also a 64-kilobyte engine-control computer in the works, which would make possible the extremely precise fuel control needed to make lean burn work.

The Quad 4 appears to be the first in a new generation of small engines from GM, engines that may become as important to the company as the V8 once was.



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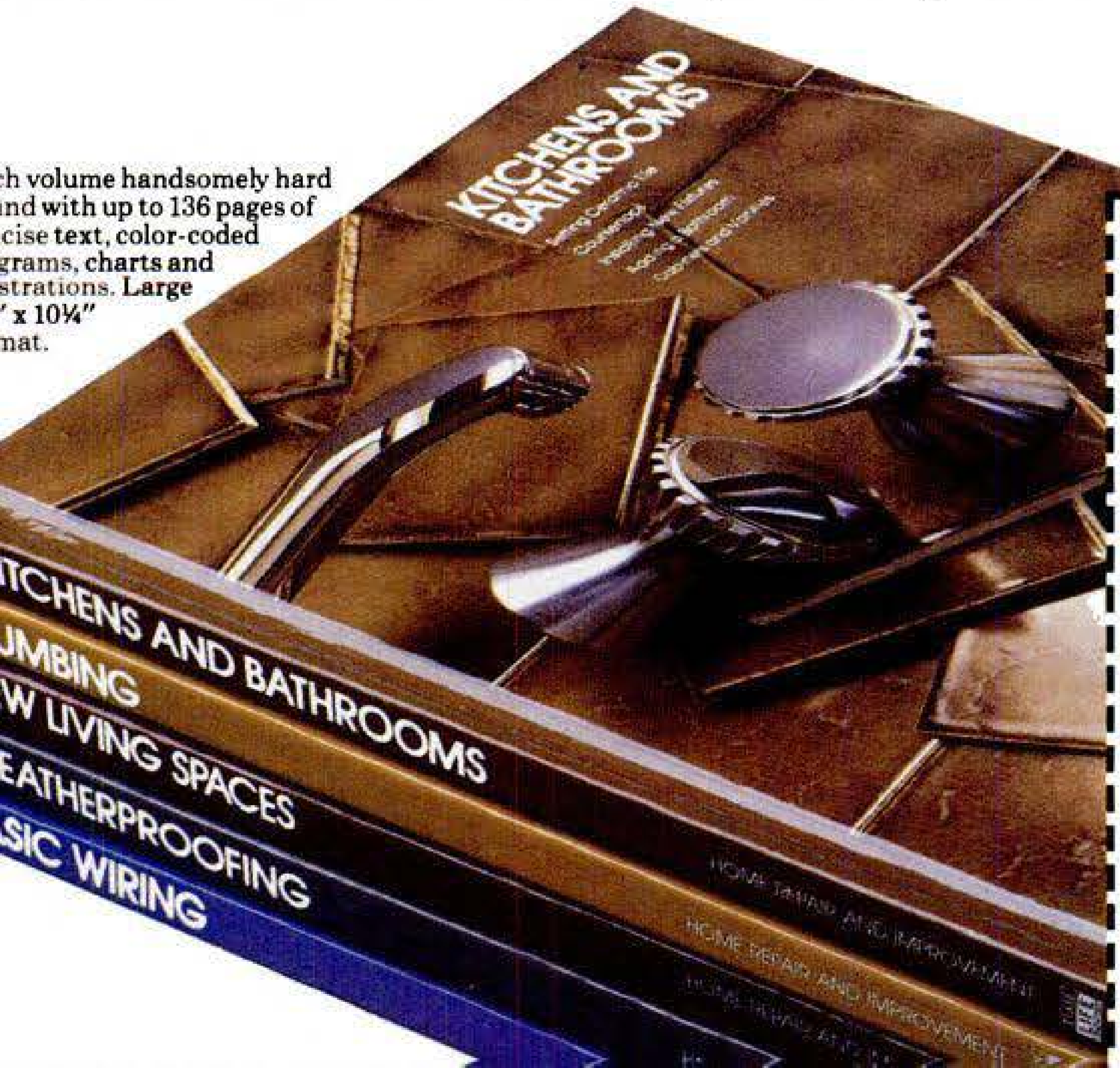

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FIRST DRIVING REPORT:
$5,000 Korean mini-car

By JIM SCHEFTER

The new Korean-made front-wheel-drive Excel subcompact is a good quality automobile—nothing fancy, just solid, basic transportation—for *$5,000*. And after driving a prototype sedan for several days in Southern California, the car seems a bargain. Comparable Japanese models have sticker prices $2,000 higher. Hyundai, Excel's maker, has a price advantage over Japanese car makers because of lower labor costs in Korea. Also, the Excel was largely designed and engineered by Mitsubishi, with Hyundai importing about 15 percent of its parts from Japan.

Throughout the car, Hyundai (Garden Grove, Calif.) sticks to time-tested automotive technology. Its 68-horsepower 1.5-liter overhead-cam engine is sufficient to haul the 2,100-pound-plus vehicle around without much hesitation, even when you floor it. The in-line four is not without refinements, however. It has a two-barrel Mikuni carburetor with an electronic feedback system that optimizes the air-fuel mixture, and a jet intake valve (in addition to the standard intake and exhaust valves) that enhances combustion efficiency by inducing a swirl in the incoming fuel charge.

Equipment is conventional. The strictly utilitarian dashboard has standard analog instrumentation. The manual steering is rack-and-pinion. Tires are Goodyear Corsa GT steel-belted radials, and the brakes are power-assisted front discs and rear self-adjusting drums.

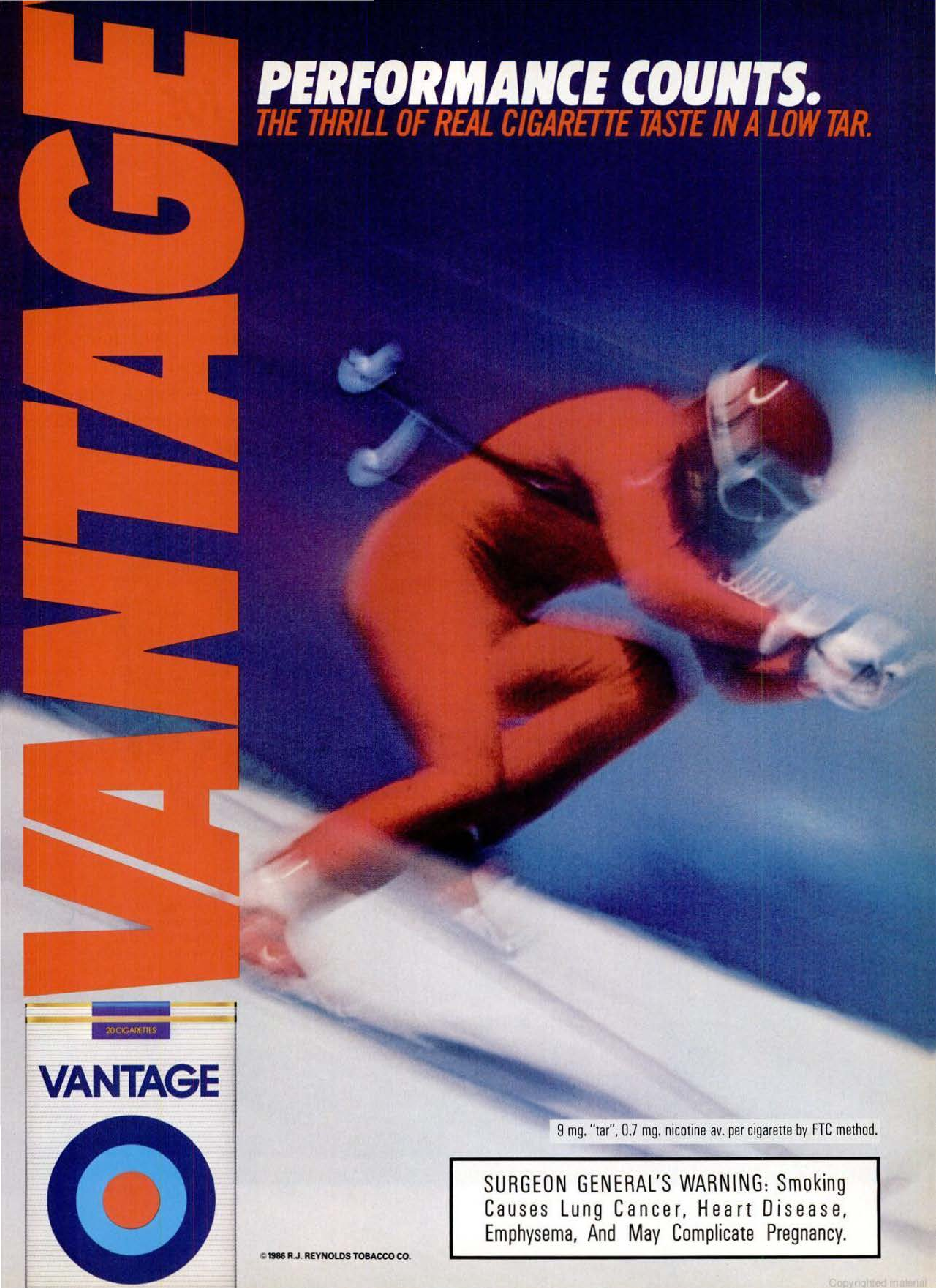
Excel's performance is pretty good. Handling, though heavy at low speeds, is relatively agile for this kind of car. The turning radius is tight. Informal acceleration runs on back roads yielded zero-to-60-mph times under 13 seconds. In the zero-to-30-mph tests, the Excel consistently turned in times of 4.2 to 4.3 seconds. At freeway speeds, interior noise was low enough to allow normal conversation, but the Excel's suspension seemed overly stiff: The car's front MacPherson struts and rear independent trailing arms failed to damp out the California freeway's little jiggles and bumps. In panic stops from 60 mph, the sedan held a nice, straight line.

Front and rear seats are comfortable, and the front and back head room and leg room are adequate. Trunk capacity is ample.

One obvious drawback to the Excel is a small 10.6-gallon fuel tank in models with manual transmissions. The automatic-transmission models have a more voluminous 13.2-gallon tank. But fuel economy is high. The EPA rates the Excel at 33 mpg for city driving and 46 mpg on the highway, which coincides with my test sedan's combined freeway and city score of 39.7 mpg.

Hyundai will offer the Excel in three Georgetto Giugiaro-styled models: three-door and five-door hatchbacks and a four-door sedan. The wheelbase for all three models is about 94 inches. The hatchbacks are 161 inches long; the sedan is seven inches longer.

The $4,995 base car comes with a long list of standard equipment, including reclining front seats, carpeting, rear window defroster, and a four-speed manual transmission. Upgraded GL and GLS versions include a five-speed manual transmission, body-colored bumpers, protective exterior moldings, dual remote-control outside mirrors, and an AM-FM-stereo cassette radio. A fully loaded GLS model, equipped with optional automatic transmission, electric sun roof, air conditioning, power windows, fog lamps, and cruise control is expected to have a price less than $8,000. Hyundai will offer the Excel through about 200 dealers in 39 states at first. The Midwest will be added in 1987.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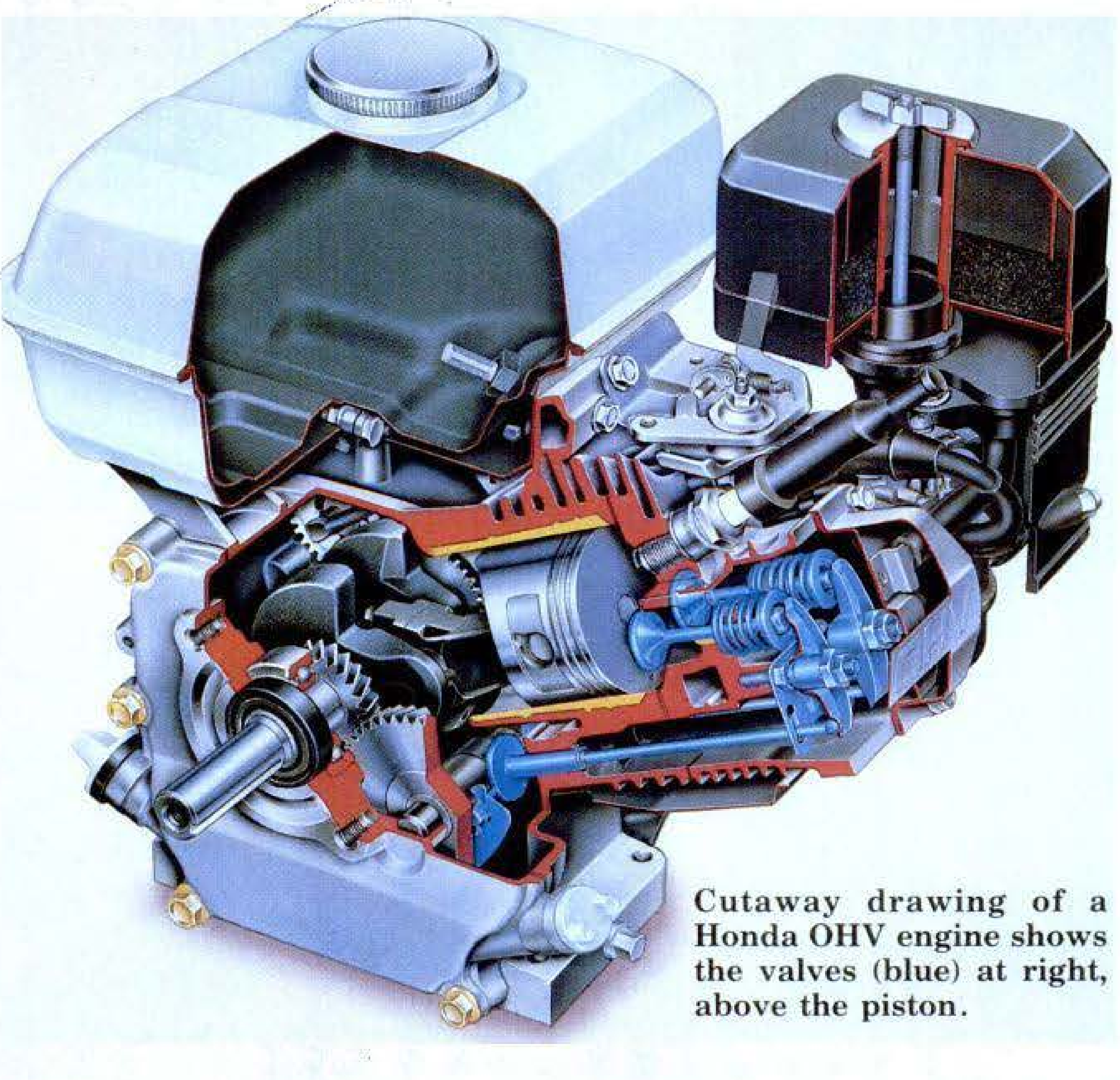
Spring is here, and you're itching to get outdoors. Whether you enjoy yard work or you just want to get the job over with to relax in the sun, you'll need good equipment. Again this year, POPULAR SCIENCE selects some of the most innovative lawn and garden products. But first, a look at what's new in the engines behind the equipment.

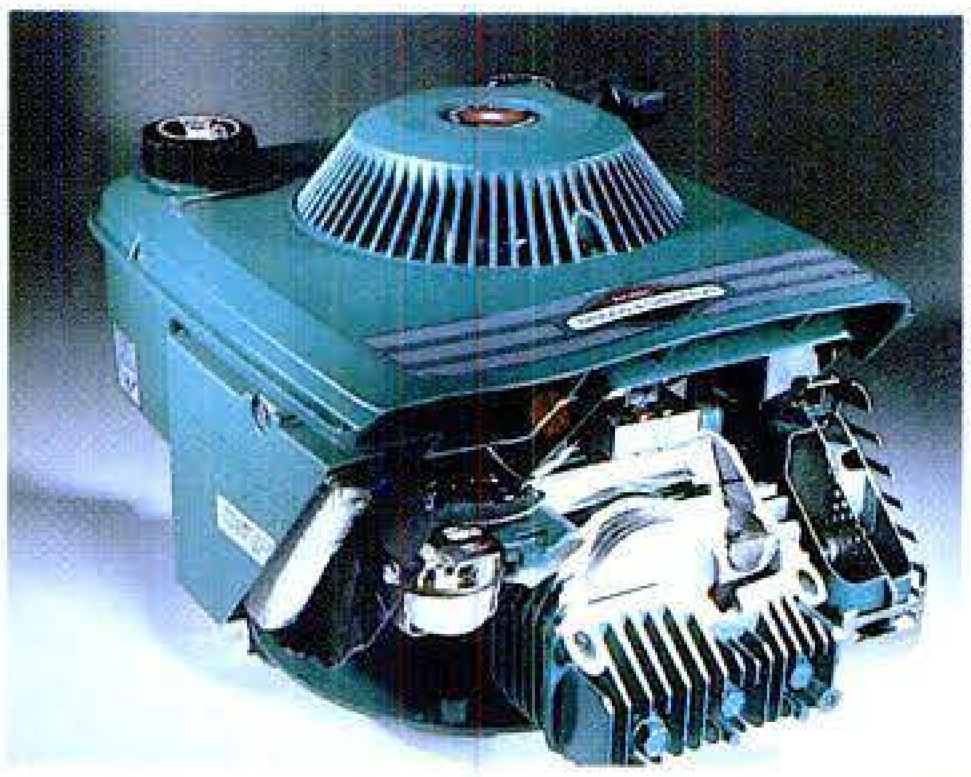


Cutaway drawing of a Honda OHV engine shows the valves (blue) at right, above the piston.

Super sophisticated small engines

As I stand in the products-testing area at Toro headquarters in Minneapolis, I remember a high-school physics lesson of 15 years ago:

Two heavy weights lie on the floor, one attached by a rope to a single pulley, the other to a complex setup of pulleys of different sizes. Members of the class try to pull each weight off the ground. Only a few of the more robust can budge the weight attached to the first pulley; *everyone* can lift the second weight easily with a speedy hand-over-hand motion. We've just learned that with a little ingenuity and a knowledge of physics, one can engineer a way to get work done with less effort.



Briggs side-valve has electronic ignition (left of piston). Note valve *in* head.

That lesson comes home as Jerry Patrin, Toro's director of engineering, new consumer products, motions toward a lawn mower with Toro's new overhead-valve (OHV) engine. I've started the 4-hp engine twice, and twice Patrin has told me I pulled too hard on the cord. "Try it again, but go *easy*," he says. I bend, grasp the starting rope with two fingers, and pull ever so slowly—it seems with barely enough effort to spin the flywheel. The mower jumps to life.

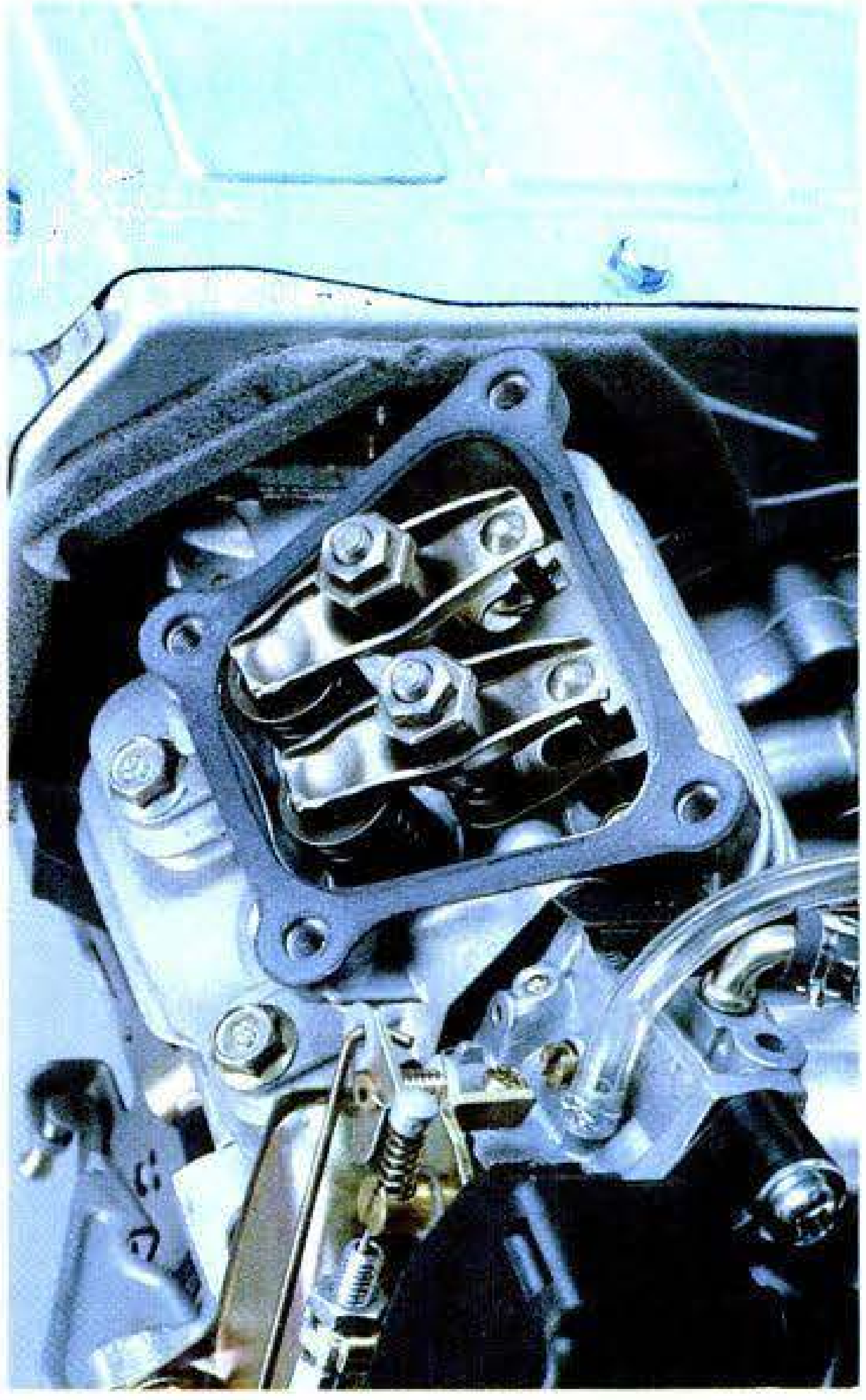
As in the pulley experiment, engineering know-how has dramatically reduced the effort needed to get work done. But that's not all. This new engine and others like it may revolutionize the entire small-engine industry.

The small gasoline engine that powers lawn mowers, generators, tillers, and the like has remained relatively unchanged for 75 years. Today it is changing fast. Borrowing from automotive- and motorcycle-engine technology, manufacturers are producing sophisticated under-5-hp engines that promise to run better and last longer than any before them.

About three years ago Honda Power Equipment introduced the first modern under-10-horsepower OHV engine. (The main difference between an OHV and side-valve, or conventional, design is that the intake and exhaust valves are located *above* the cylinder head instead of *in* it.) But OHV technology isn't new. It's been common for years in cars, and Tecumseh has produced 12–18-hp OHVs since the '70s.

I asked Bob Jacques, Honda's manager of engine sales, why it took so long for OHV to come to smaller engines. "I think people were kind of complacent about what they had and took the path of least resistance," he said. "They didn't feel a need to come up with anything significantly better."

But is an OHV that much better? "With the valve over the head," Toro's Patrin says, "you have a bigger combustion chamber in the same size engine, higher compression for more power, better cooling for longer valve and cylinder-head life, easier access to engine parts, and less vibration and noise." The OHV makers also incorporate features like automotive-type lubrication systems and electronic ignition and decompression systems to provide easier starting. "All these things are a benefit to the consumer, at a comparable cost," says Patrin. "I think the entire industry will go this way."



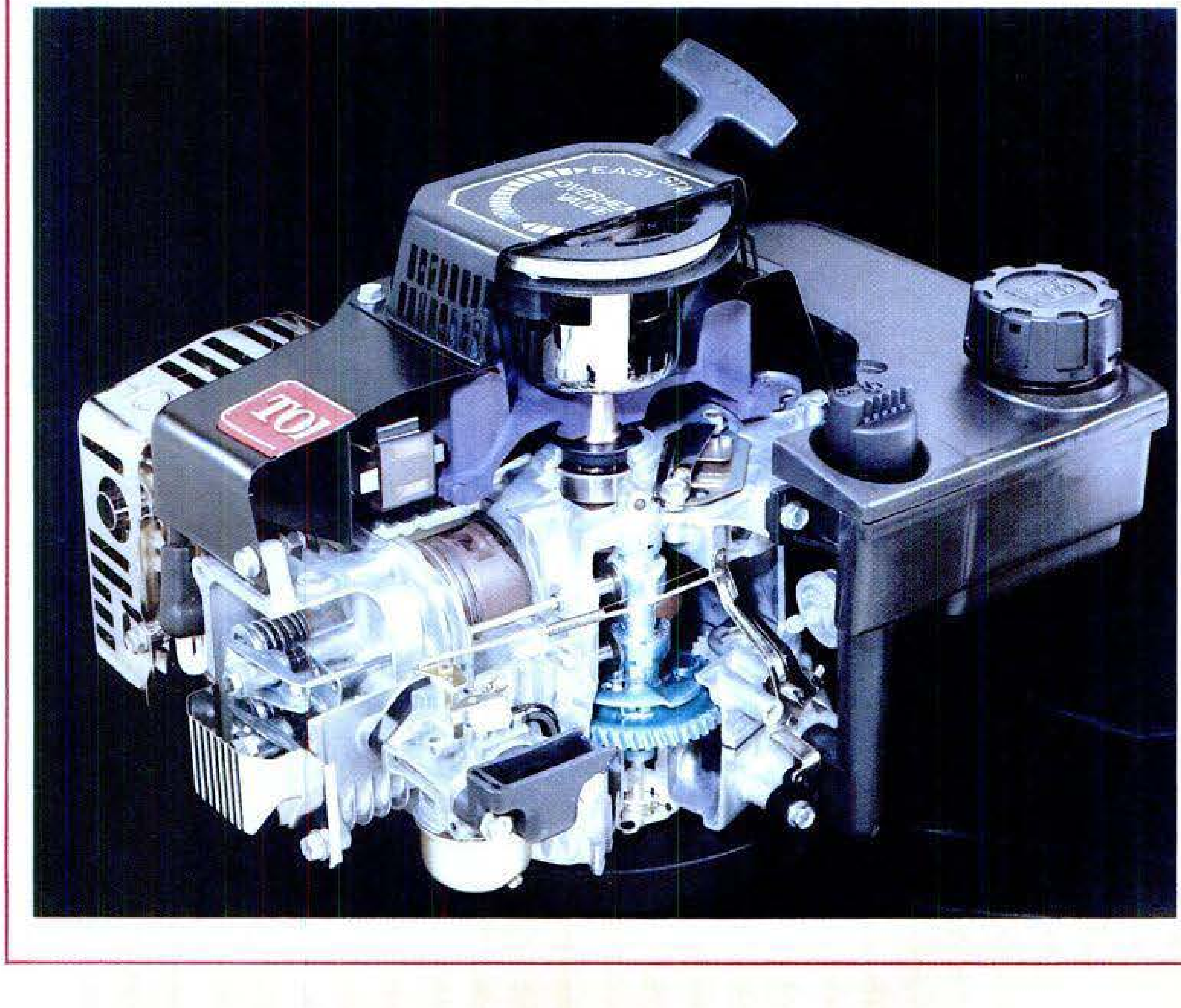
View of Yamaha engine shows rocker arms, demonstrates ease of repair.

Honda now has a complete line of OHVs, from 3.5 to 13 hp. Yamaha uses OHV engines for its generators. Kawasaki and Mitsubishi provide small OHVs to the industry on a limited basis. And Toro, in a joint effort with Suzuki, recently came out with the 4-hp OHV engine I saw.

What of the largest producer of small engines, Briggs & Stratton? All Briggs's small engines are side-valves whose basic design has changed little over the years. But I have been told there is some interest in OHV design, and that the company is taking a serious look at the technology. Presently, however, Briggs includes on some engines such advanced engineering enhancements as a low-oil shutoff system, float-feed carburetor, and electronic ignition. (Tecumseh and Kohler offer similar features, but they specialize in engines over 8 hp.) These are all developments that have trickled down from automotive technology.

What of the future? Says Honda's Jacques, "Not much has changed in the last 75 years. The next big change will be something major, like a frictionless or totally ceramic engine. It's coming."—*Timothy O. Bakke*

Toro uses horizontal design (compare with Honda). Note rocker arms (left).



New products for LAWN & GARDEN

STIHL
STIHL

Luggable cutting power

Power without weight is the design goal of its 034 series of chain saws, says Stihl (536 Viking Dr., Virginia Beach, Va. 23452). A 3.44-cu.-in. engine gives this mid-size gasoline-powered saw a high power-to-weight ratio; with a 16-in. bar and chain it weighs 14.5 lbs. Stihl equipped the $450 034 with its Quickstop inertia chain brake, which uses a friction band that encircles the clutch drum. The brake works automatically in the event of kickback, or it can be engaged manually. A chain catcher, chain guard, and safety throttle lock are also standard. The 034's breakerless ignition is controlled by an electronic module that's warranted for the life of the saw. The chain tensioner is accessible through the chain-sprocket cover, making tension adjustments easier for the operator.

Tough shredder

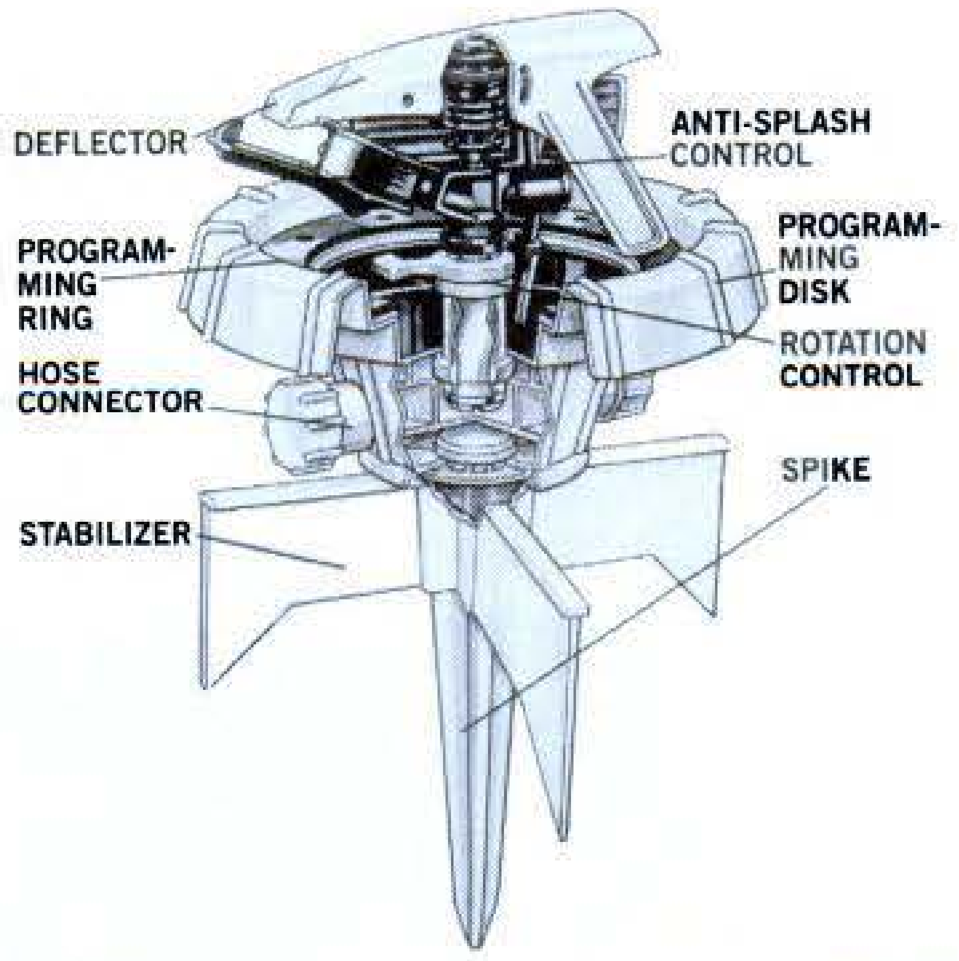
Some outdoor power jobs are rougher on equipment than others. Chopping up tree trimmings and garden waste and reducing stalks and wood to shreds and chips by brute force is one of those jobs.

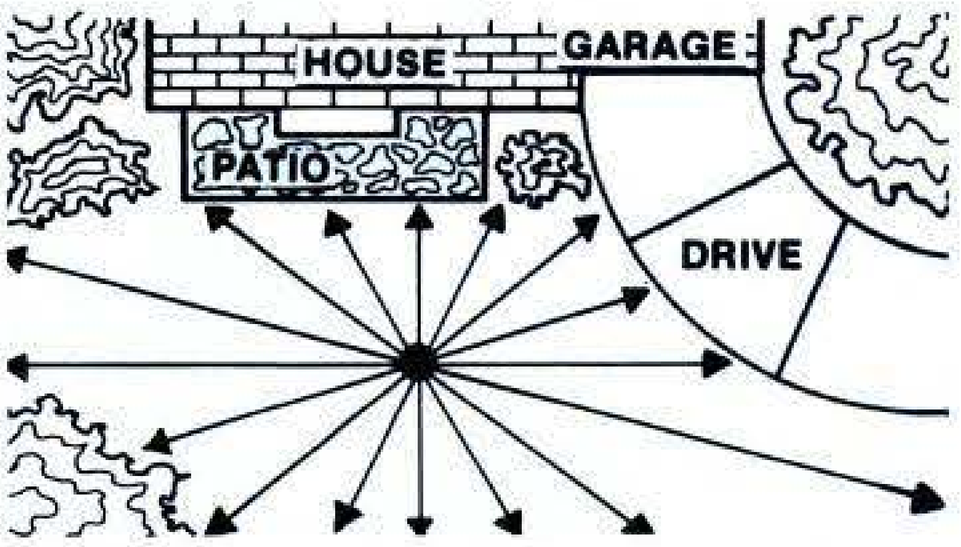
The model 500 shredder from Roto-Hoe Co. (100 Auburn Rd., Newbury, Ohio 44065) has three engineering innovations that enable it to tackle those rugged tasks. First, its engine is remote from the debris. All impact loads are cushioned by a drive belt and a spring-tensioned belt-tightening clutch. Second, shredding is done by the hammer-mill method, in which loosely suspended steel flails chop the debris against hardened grate bars and a sizing screen to produce a fine mulch. Accidentally drop in a rock, and you'll hear a lot of noise, but the flails will simply pivot and yield, and no harm will be done. Third, the 1-in.-dia. mill shaft is mounted on two outboard Timken bearings, vastly different from imposing such loads on engine bearings.

To chop up tree prunings and heavy cornstalks, the 500 has a side chute: Shove in cuttings up to 1¼ in. in diameter, and a rotating knife shears them against a hardened-steel cutter bar. The hammer mill does the rest. The shredder comes with one of two engines: 4 hp ($459) or 5 hp ($489).

Stand-up clipper

A grass shear is hard to beat for precise trimming, but it condemns you to crawling around the yard on your hands and knees. Black & Decker's model 8202 grass groomer is designed to safely trim near delicate plants with the stand-up convenience of a weed trimmer, says B&D (515 Glebe Rd., Easton, Md. 21601). Price: $30.





Cut-to-fit downpour

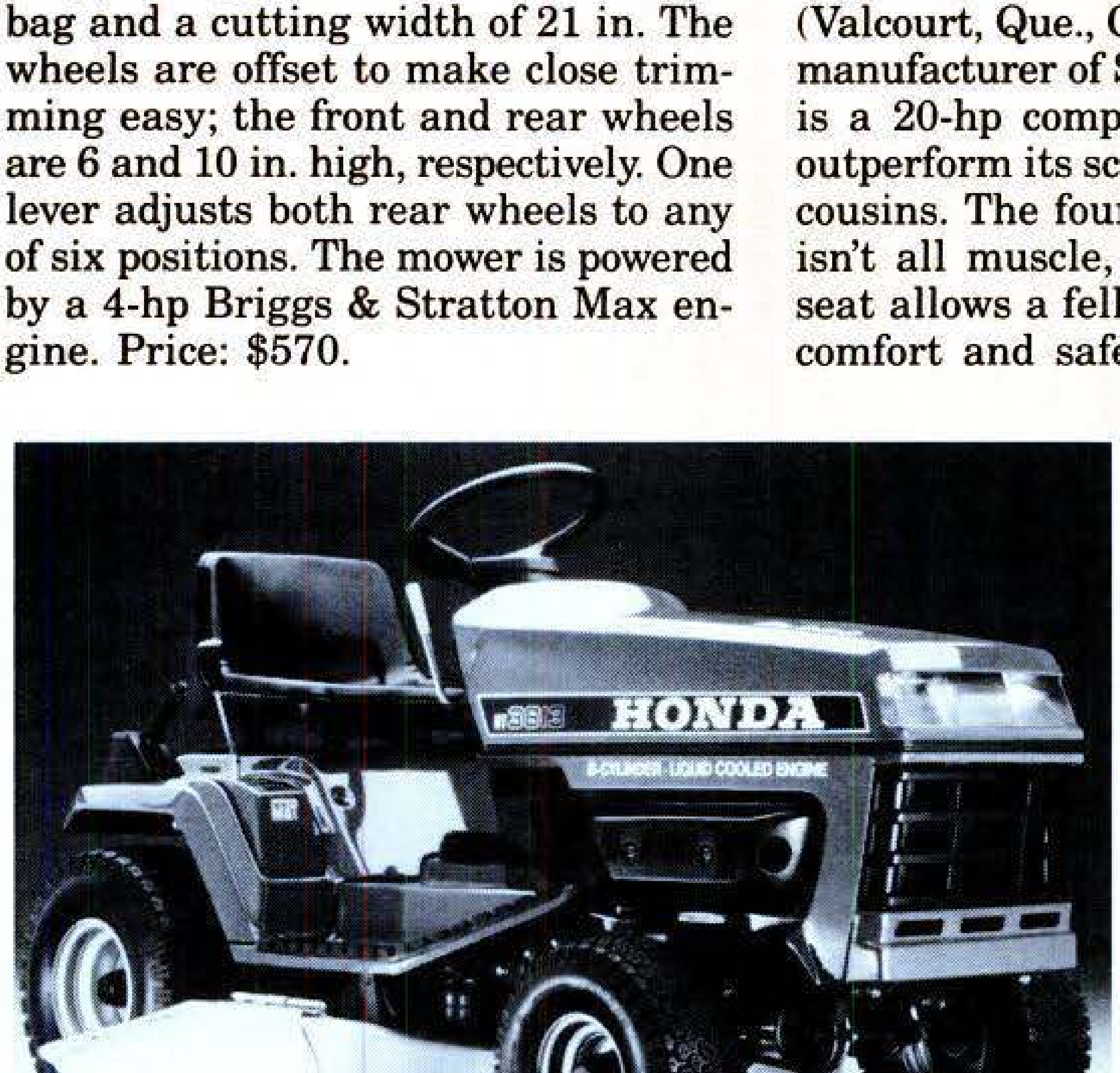
How do you water an L-shaped lawn without drenching whatever else is nearby? Pattern Master is a programmable sprinkler that puts the water only where it's needed. Watering distance is programmed by raising or lowering mechanical slides with finger pressure. It costs $25 (Gilmour Mfg. Co., Box 838, Somerset, Pa. 15501).

Four-in-one mower

The Simplicity model 1421PP is easy to rig as a self-propelled rear bagger, mulcher, side-discharge mower, or leaf chopper-bagger. It has a three-bushel bag and a cutting width of 21 in. The wheels are offset to make close trimming easy; the front and rear wheels are 6 and 10 in. high, respectively. One lever adjusts both rear wheels to any of six positions. The mower is powered by a 4-hp Briggs & Stratton Max engine. Price: $570.

Tractor built for two

You might think this slope-nose two-seater with the roll bar looks more like a dune buggy than a workhorse. But the MPV-20 from Bombardier (Valcourt, Que., Canada J0E 2L0), the manufacturer of Ski-Doo snowmobiles, is a 20-hp compact tractor that can outperform its scrawnier lawn-tractor cousins. The four-wheel-drive vehicle isn't all muscle, though. The second seat allows a fellow worker to ride in comfort and safety. And the sloping hood gives you a better view of where you're going. You can use the under-$7,900 MPV-20 as a snow thrower, mower, tiller, front loader, backhoe, or plow. And you won't need tools to hitch those implements to the vehicle's front: They push into special brackets and are secured with cotter pins. There's a standard three-point hitch in back. Optional equipment: smooth-treaded tires for lawn work, power steering, rear-view mirrors, and front power takeoff, which is needed to perform some tasks.



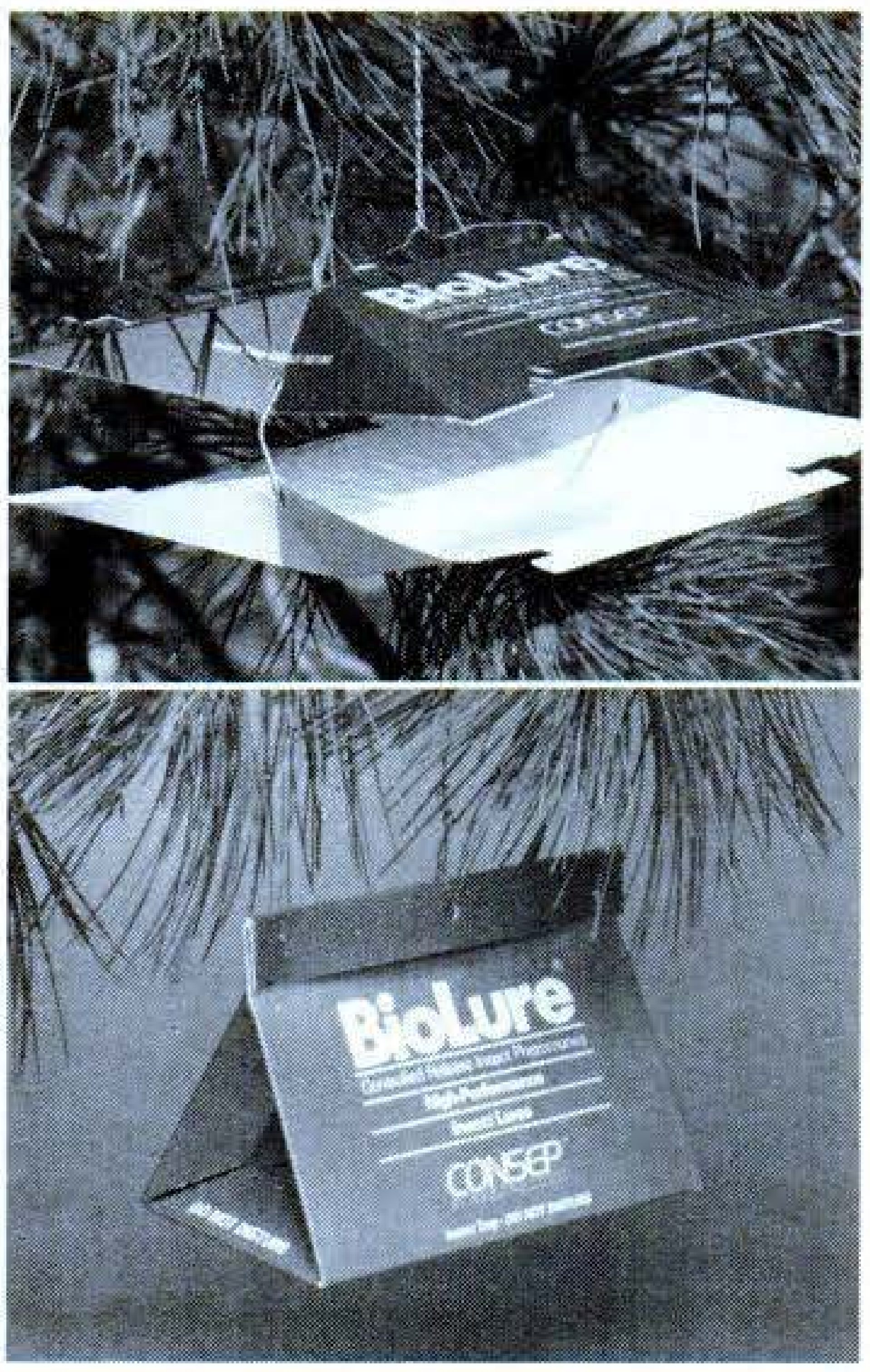
Liquid-cooled engine

Fuel savings—that's the reported benefit of the twin-cylinder liquid-cooled engine on this 13-hp tractor from American Honda Motor Co. (100 W. Alondra Blvd., Gardena, Calif. 90247). The tractor is also easy to operate: You change gears by shifting a floor-mounted lever—there's no clutch to work. For safety, the cutting blades will operate only when someone is sitting in the weight-sensitive seat. With twin headlights, fuel gauge, and temperature warning lamp and buzzer, it's $2,748.

Blowerless bagging

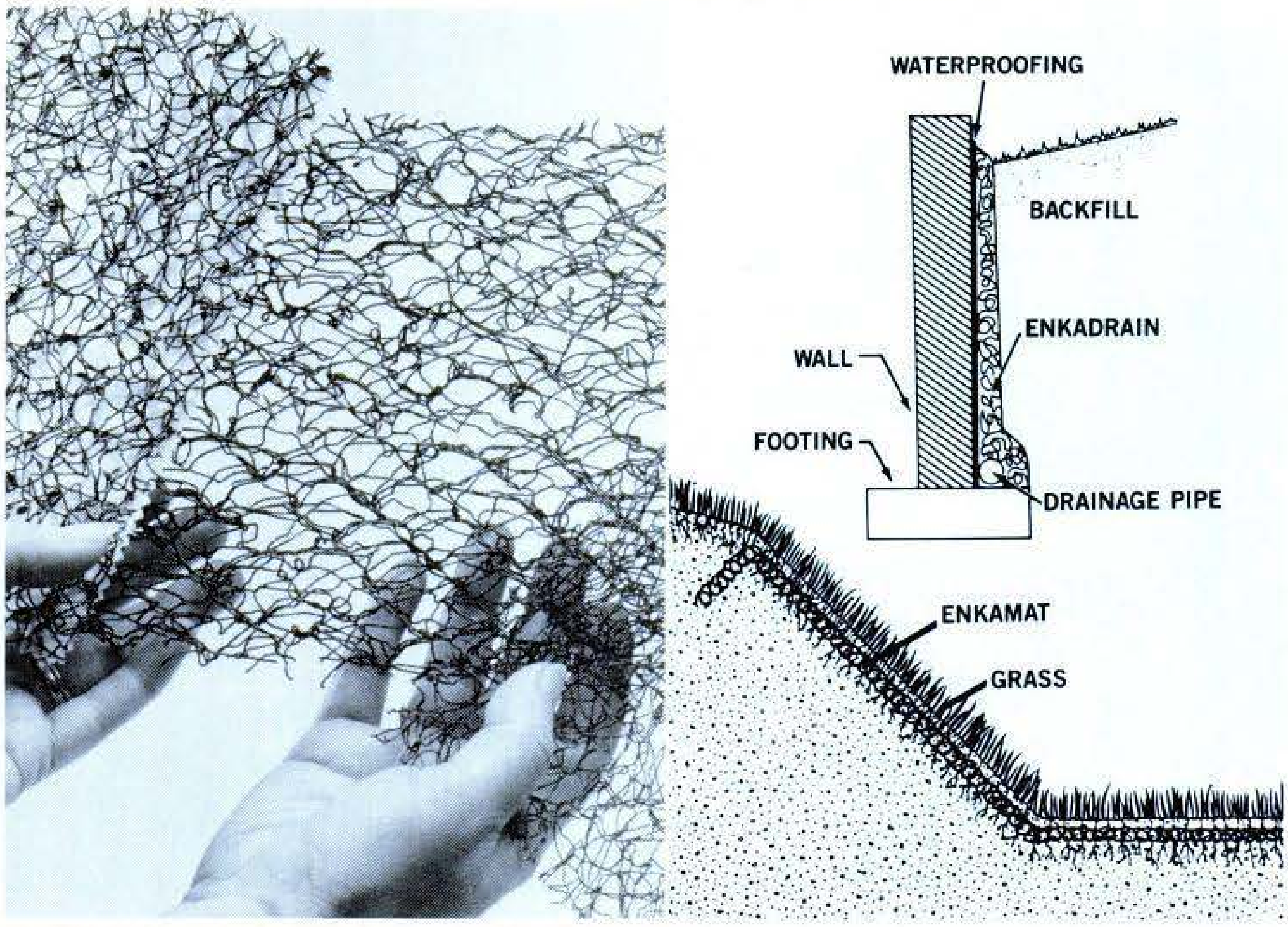
Looking for a tractor that can cut your mowing time? Then this lawn tractor from Toro (8111 Lyndale Ave. S., Minneapolis, Minn. 55420) may be for you. Powered by an 11-hp engine, the $2,340 tractor uses twin blades to cut a 38-in.-wide swath. And there's no need to spend money on a blower: Airflow from the blades pushes the cut grass over the specially designed deck and into the bagging chute. The five-speed tractor also features an electromagnetic switch that drops the deck for cutting.

New products for LAWN & GARDEN



Sexy pest control

No, they're not new tent designs for leprechauns. They're insect traps, for no-insecticide control of pests in your garden or orchard. BioLure traps, from Consep Membranes (Box 6059, Bend, Ore. 97708), have a sticky floor and use pheromones (sex scents) to attract flying insects. When an insect enters the trap and lands, it sticks to the floor. The pheromone is time-released through a special membrane; the rate of release is designed to mimic the natural scent attraction of the insects you're after. Consep says it has formulations for 36 insect species, and the traps last eight to 26 weeks, depending on the insects' flight season. Kits are available at lawn-and-garden centers; price varies with application.



Tangled webs for erosion, drainage

The strange material I'm holding in the photo above would make a fine door mat or pot scrubber. But it has bigger ambitions. The two samples in my right hand are for erosion control; the one in my left is used to promote drainage.

They're called Enkamat and Enkadrain, and their tangled threads are extruded nylon. "The monofilaments are brought together while the nylon is still molten," explains P. L. Skoglund Jr., American Enka Co.'s director of Enkamat Systems. Thus they stick and form an open-work web. Though these materials are intended for commercial use, they can be handy around the home and yard. There's one handicap, however: You can buy them only by the roll, which is large and expensive. If you don't need that much, you could get together with a neighbor who has similar problems to solve.

What kinds of problems? Steep slopes, for example. They're notoriously difficult places to establish a stand of grass. Enkamat can help. "You lay the matting, fill it with soil, and sprinkle grass seed over it," instructs Skoglund. The matting holds the soil and keeps the seeds in place. As the seeds grow, roots penetrate the matting, creating a stable surface.

Enkadrain is Enkamat with a polyester fabric heat-bonded to one side. It is used in place of gravel to permit water drainage. The fabric keeps soil from clogging the matting. Enkadrain's most common residential use is around basement walls (or earth-sheltered houses), as illustrated. The Enkadrain is cut to length (Skoglund recommends hedge shears), then glued to the top of the wall (fabric out) with construction adhesive. Ideally, such drainage is installed when the house is built. But if you have a leaky basement, a possible solution is to have the foundation dug out. Then you can install Enkadrain all around. "That's usually $5,000 to $8,000 a lick to repair what should have been done for $1,000 in the first place," says Skoglund. Enkadrain also can be used for smaller tasks, such as lining planters.

Enkadrain (for use down to 10 ft.) costs $225 to $250 for a 35-sq.-yd. roll. Enkamat comes in 9- and 18-mm (0.35 and 0.7 in.) thicknesses in 173- and 116-sq.-yd. rolls, respectively. Price for either is around $775, but volume discounts are available. For the address of a local distributor, write to American Enka Co., Enka, N. C. 28728. —*V. Elaine Gilmore*

Two-cycle trimmer

Electric hedge trimmers are lightweight, but they're often lacking in power, and the cord can be difficult to deal with. Now you can have no-cord gas power without the weight. The HT-18 trimmer from Homelite/Textron (14401 Carowinds Blvd. Charlotte, N.C. 28217) has an 18.4-cc two-cycle engine and 17-in. blade and weighs 10 lbs. $160.

Sure you want a Snapper. And now's the time to get one. Your local dealer is making it a snap to own the best with unbeatable deals and easy credit.

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Choose from a 19" or 21" push mower with SNAPPER's Hi-Vac® cutting system. Vacuum action stands grass up for an even cut and removes clippings, leaves, and pine straw. So buy one** now and get your choice of:

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SNAPPER's self-propelled mowers have all the power for lawn care. 6 forward speeds, a 4 HP engine, and our patented Hi-Vac® deck take the effort out of your work. Buy one** now and receive your choice of:

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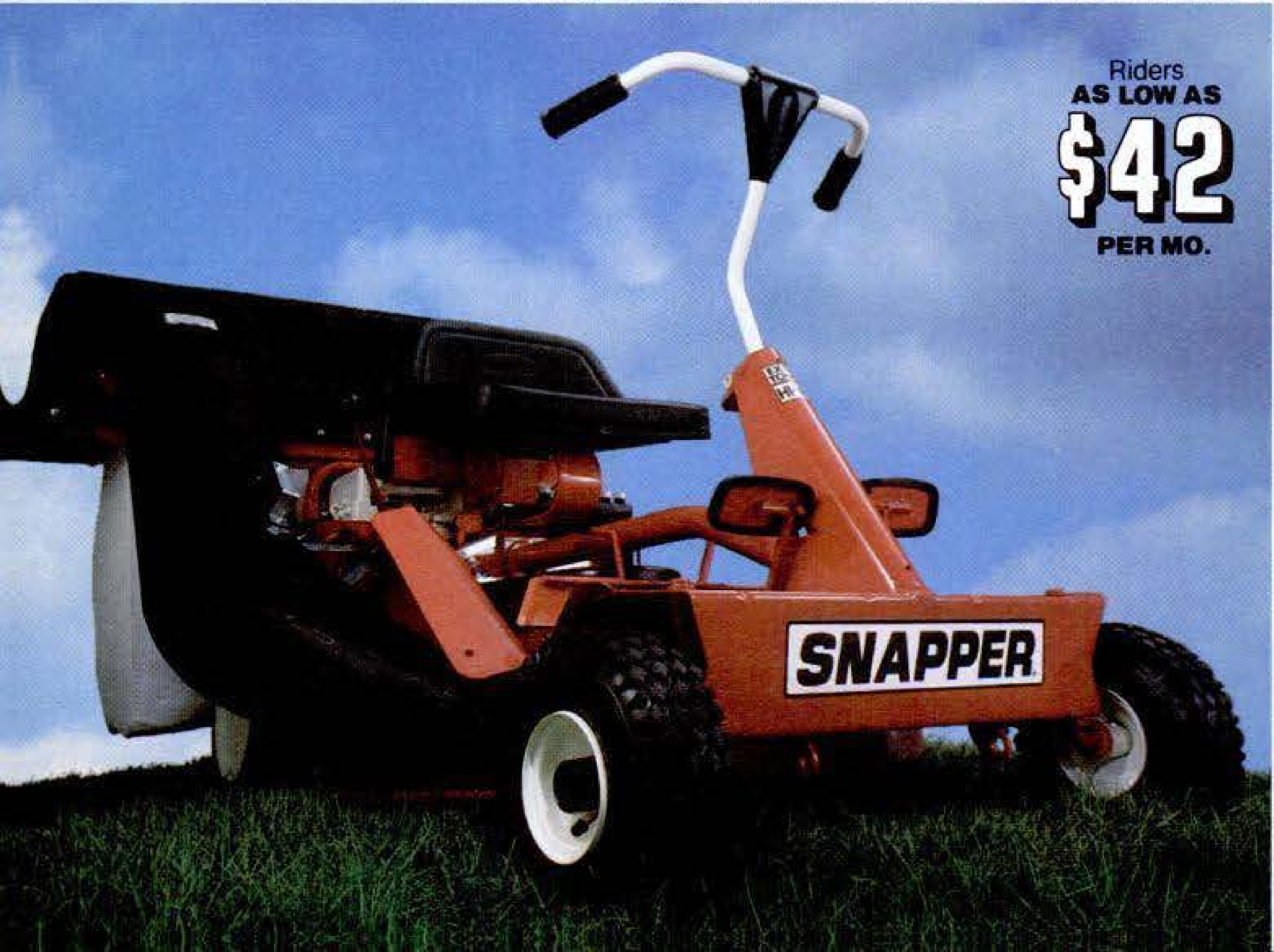
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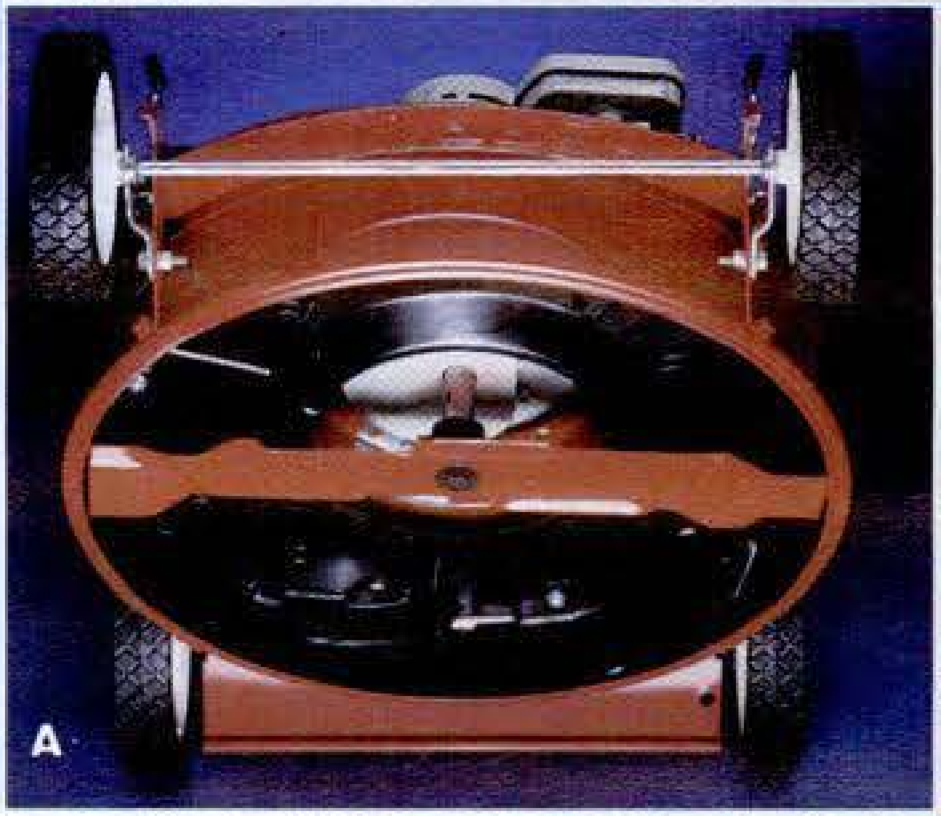
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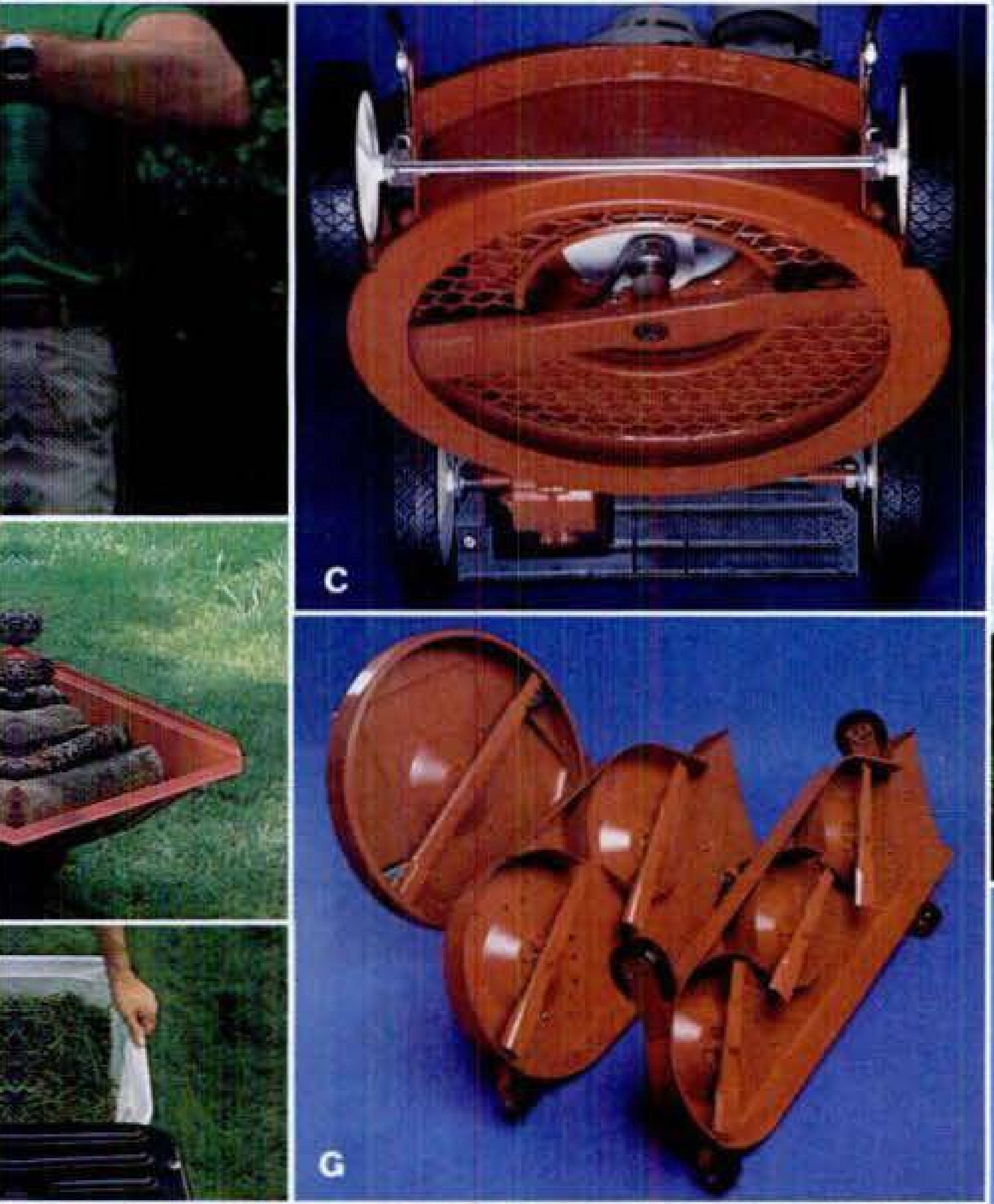

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K. Hiller-Furrower, retail value $79.95
L., M. Plow Kit, Cultivator and 2 gauge wheel kits, retail value $139.95
N. Dozer Blade, retail value $129.95
FREE: (rear tine tiller attachments)
K. Hiller-Furrower, retail value $79.95
M. Cultivator, retail value $109.95

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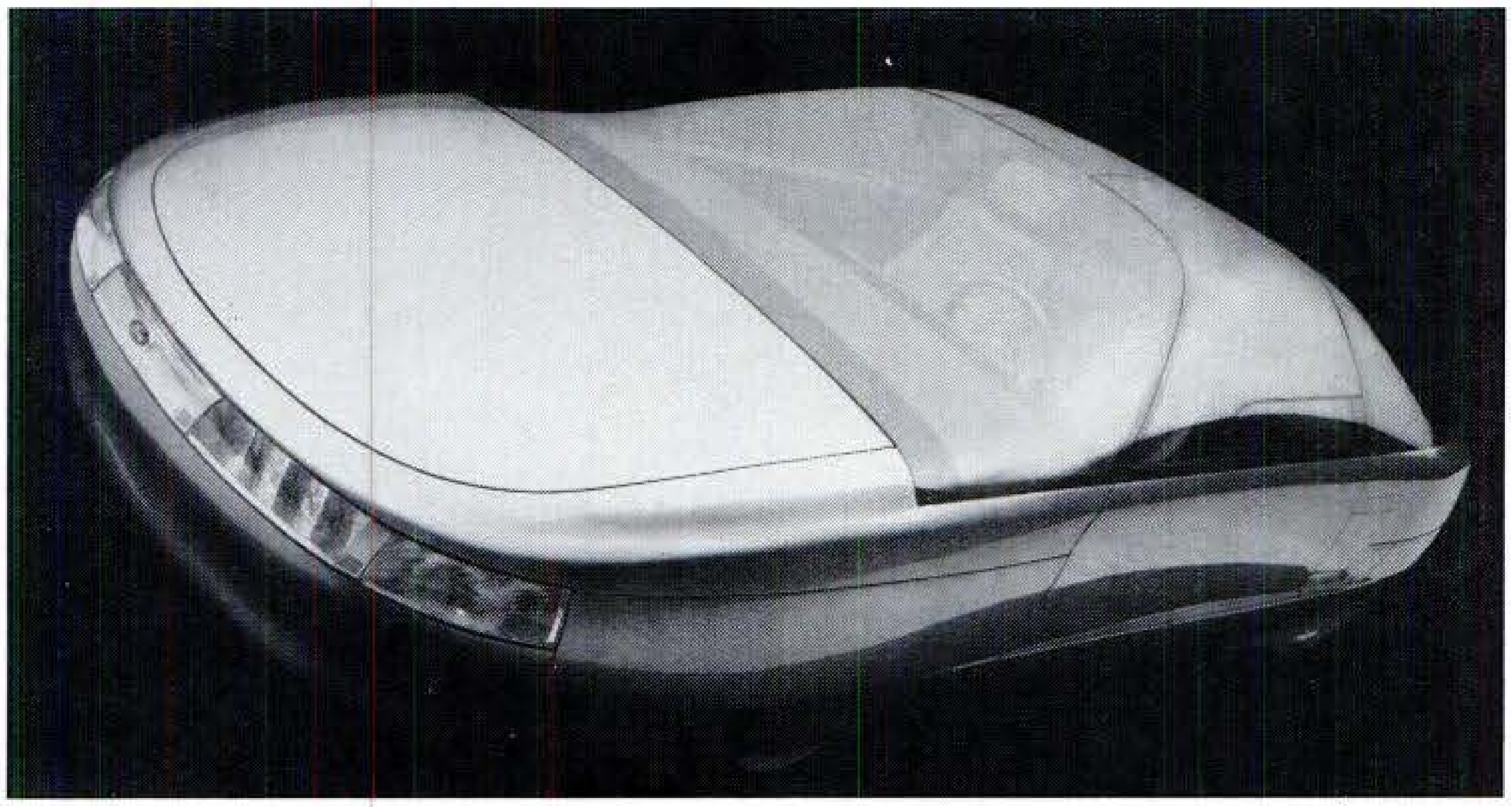
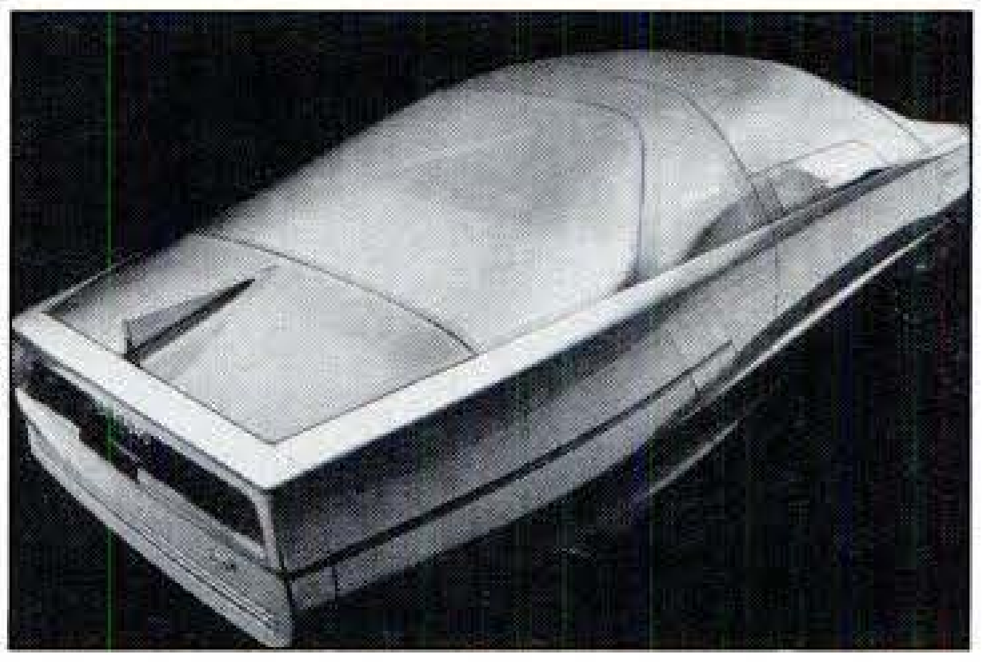
Sleeker than a fighter plane:

Ford's Probe V



By JACK KEEBLER



DEARBORN, MICH.

The filmy blue cover whispered gently off the soft curves of the Probe V concept car's gleaming plastic skin. Even before the gauzy sheet had settled to the design center's floor, the shutters of several cameras were snapping hungrily. Suddenly, my eyes, which had been skimming the fluid shape, were drawn to what looked like a shark's dorsal fin sticking boldly, almost annoyingly, out of the rear deck. Was this somebody's idea of a joke?

Ford engineers don't consider the Probe's "vertical stabilizer" a joke. The stabilizer's job, according to the unsmiling experts, is to enhance the vehicle's stability when it is experiencing extreme side-wind forces. And it's just one of many innovative and functional features incorporated into Ford's rolling aerodynamics laboratory. Some of the others include:

- Flush glass and sliding doors.
- Space frame and thermoplastic skin.
- Skirted wheel openings.
- Turbocharged mid-engine design.
- Eight mini-quad headlamps.
- Telescoping instrument panel and heads-up display.
- Electronic vehicle attitude control.

Ford had two objectives for the project. The main one was to beat Probe IV's already extremely low 0.15 drag coefficient. Probe V's drag coefficient is 0.137. Probe V has so little wind resistance that it can sustain 50 mph with a little less than five horsepower, claim Ford engineers. The second objective was to give Probe V better road holding and stability.

To achieve the low drag coefficient, the form of the vehicle was developed first. The flush glass, including the side glass, windshield, backlight, and deck lid, were then sculpted into the optimized body shape. It is a design trend that engineers promised for future production models.

The fiberglass model shown in Dearborn is the first of three Probe V models. Another model will be executed in steel at the Ghia studio in Turin, Italy, and will be shown at the Tokyo auto show. The final version, due in the spring, will have a steel sub-frame and plastic body panels similar to Pontiac Fiero's.

Probe V's front and rear wheels are fully skirted. The front wheels are covered with a soft pliable material that flexes when the wheels turn. Louvers in the rear quarter panel behind the door are cooling air intakes for a midship-mounted turbocharged four-cylinder engine. The louvers open when the vehicle is in motion. Full-width slots in the rear of the car vent the air pulled in through the louvers. For engine access the backlight pops up and slides back like a fighter airplane's canopy.

Like the sliding door on the side of a van, Probe V's doors also pop open and slide back. They make entering and exiting the low car easier, even for tall drivers.

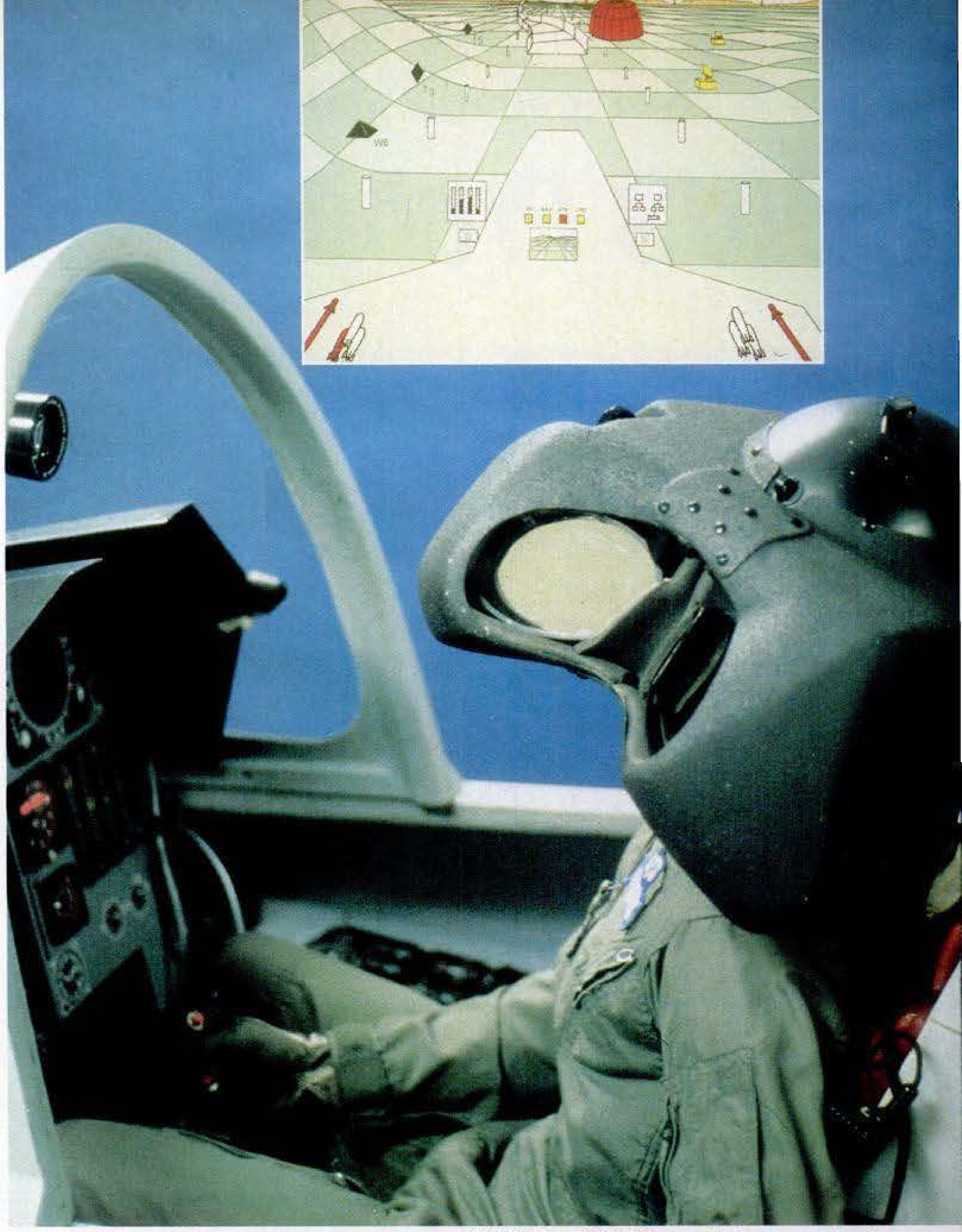
To light the new vehicle's way, Ford incorporated a new type of headlamp called mini-quads into the car's rounded nose. Each of the eight lights (four to a side) is about the size of a business card, and they are ensconced in a thick layer of clear plastic that wraps around the front of the car.

How did Ford achieve its second objective—greater stability? "We incorporated many air-management techniques from aircraft and race cars," said Darrell P. Behmer, a 24-year-old Ford designer. "That meant shapes and fins that would enhance the coefficient of drag and stability of the vehicle."

Behmer came to Ford just weeks after graduation from the Center for Creative Studies in Detroit. John Betti, executive vice president of technical affairs and operating staffs, claims that Behmer was able to solve some of Probe V's most knotty technical problems because "he didn't understand that certain things 'couldn't' be done."

Why is Ford exploring aerodynamics with projects like Probe? "Aerodynamics is a real gold mine," says Donald F. Kopka, vice president of design. "The aerodynamic design of our cars has alone contributed one-and-a-half miles per gallon to our Corporate Average Fuel Economy [CAFE]. If you consider that it costs about two billion dollars to achieve a one-mile-per-gallon saving through down-sizing or replacing power trains, aero's one-and-a-half-mile-per-gallon contribution represents a three-billion-dollar cost reduction." And beyond the fuel savings, proper aerodynamics enhance engine cooling, reduce wind noise, and improve road holding. Concept cars serve two other important functions, says Kopka: They give management the opportunity to live 10 years in the future, and they give Ford an opportunity to do consumer research with real products. PS

With bug-eye helmet, pilot speaks, plane obeys



With the VCASS, a pilot sees a display of symbols for weapons, targets, potential threats, and controls superimposed on the outside scene. A lightweight version of the 3-lb. helmet may be used in Army helicopters.

By BEN KOCIVAR

A fighter plane breaks into enemy airspace. The pilot is flat on his back, his arms tight to his sides —the only way to withstand high-*g* maneuvers. But everything he needs to see—including the controls and the scene outside the cockpit—is projected onto the inside of his helmet's monster lenses. He scans the picture, looking for a symbol of the primary target. A glance at the weapons indicator activates the "Select" button. Now he's ready to attack. "Lock on," he whispers, and a switch automatically flips. A pause, then, "Fire."

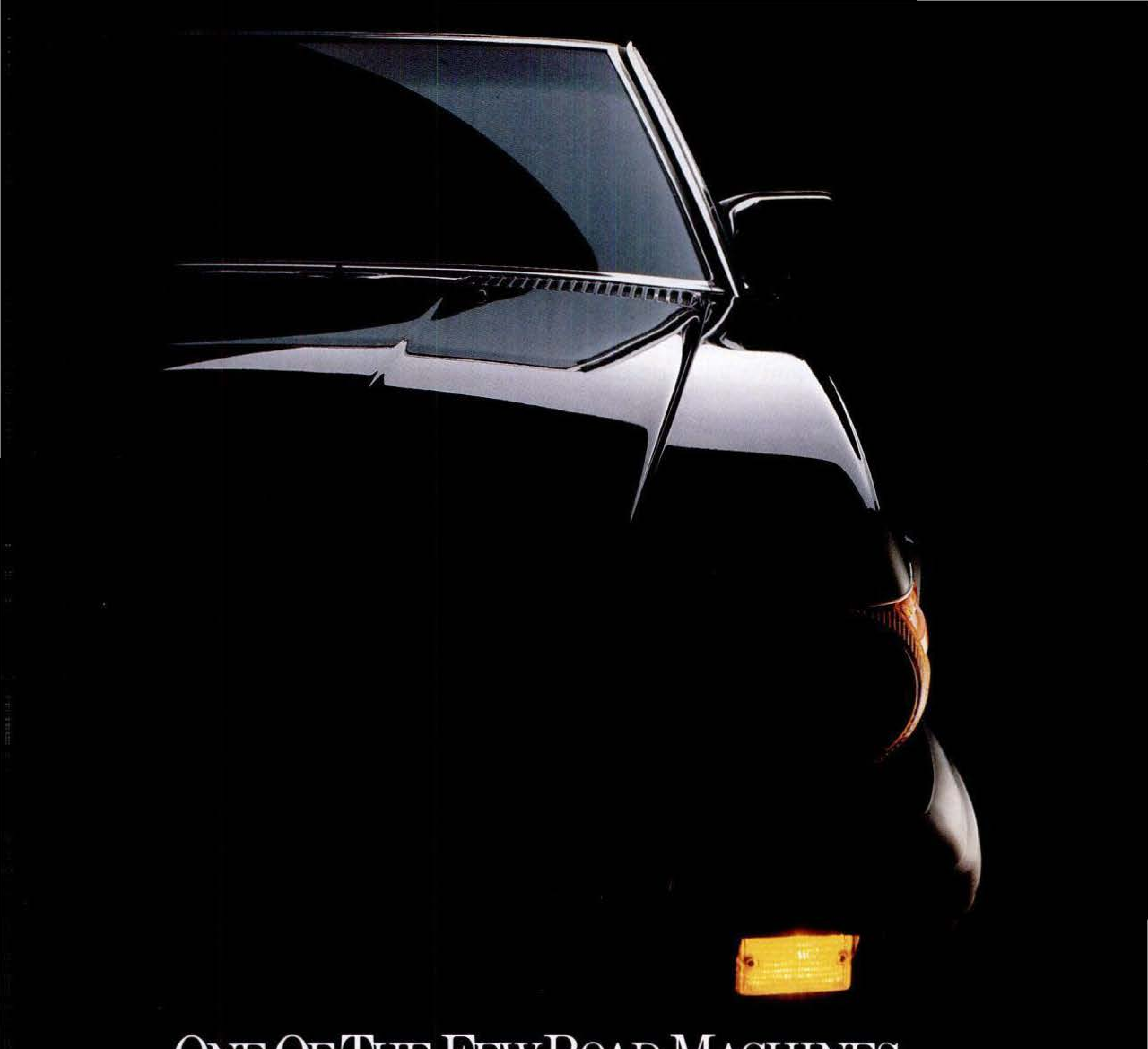
An outlandish scenario drawn from comic-book adventures? No. Now there's a remarkable helmet called VCASS, for Visually Coupled Airborne Systems Simulator, developed at Wright-Patterson Air Force Base, in Ohio. The helmet recreates scenery, controls, and other flight data—just inches in front of the pilot's eyelashes. And it enables command of an aircraft by voice, pointing (with the aid of a sensor sewn into a glove), or looking at specially designed switches.

VCASS was originally conceived as an inexpensive flight simulator, but it may prove essential to next-generation fighters. "The trend of future supersonic aircraft is to have small cockpits with reclining seats," says Thomas Furness, VCASS program manager. "These are designed to help pilots withstand the high-*g* forces of advanced combat maneuvering so they don't black out. With the pilot reclined, he can't see a conventional cockpit panel. VCASS will get the information to him."

VCASS has a one-inch-diameter TV picture tube with high resolution, contrast, and brightness. "Signals come into the TV from any source on the aircraft, such as scan-converted radar, low-light TV, and computer-generated information," says Dean Kocian, project engineer and designer of the tube. He also designed the optics package, which converts images from the TV tube into a three-dimensional, panoramic 120-degree picture that's projected on the helmet's bug-eye lenses.

That picture changes to follow the movements of the pilot's head. Pulses from an electromagnetic source behind the cockpit seat are picked up by sensors on the helmet, which give the computer data on the location and position of the pilot's head. The optics then project the corresponding images.

Only a fraction of the over 100 cockpit switches are designed to be activated by voice or eye or hand movement. "You wouldn't replace each switch in the cockpit with one represented in the VCASS that can be specially activated, although you could," says Kocian. "You have to be selective. For example, only short verbal commands, such as selecting a radio-signal frequency, can buy a performance increase. And to give a pilot visual feedback so that he knows which switch he's tripping, you can mark those switches with a cursor."



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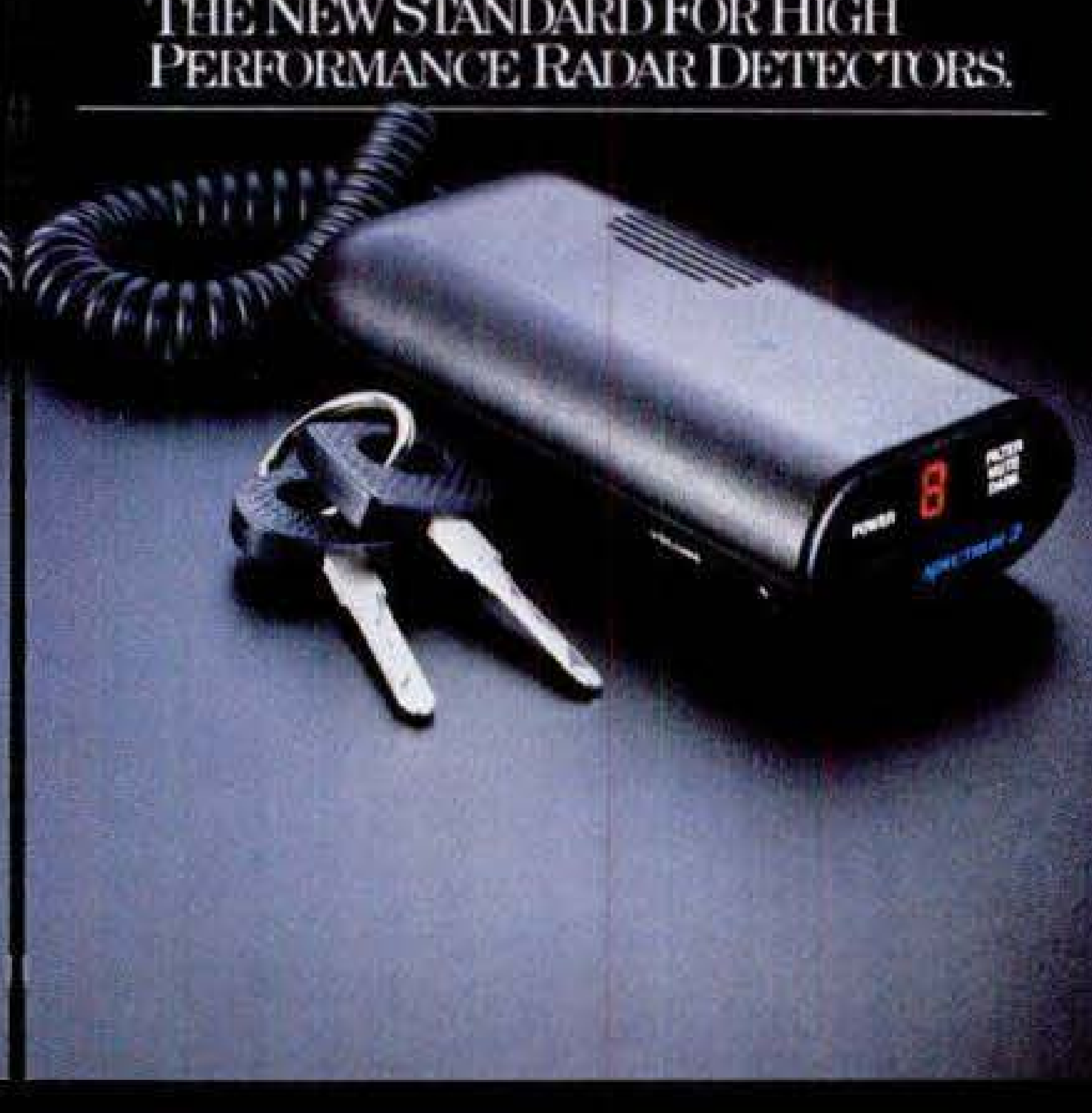


Under this unit's sleek exterior lies the power of unprecedented sensitivity.

What separates Spectrum 2 from all the rest, however, is its unique warning system. A combination of an audible alarm and a numeric display – a readout between 1 and 9 that visually tells you when you have locked onto police radar and just how quickly you need to react. A photo cell automatically dims or brightens this display to make it easier to read in any light.

Spectrum 2 also boasts a microprocessor which reports a separate warning for X and K bands, allows you to set your alarm's initial response level to avoid annoying false alarms, and controls many other functions – all with the mere touch of a single button.

Or you can simply plug your unit in and drive.

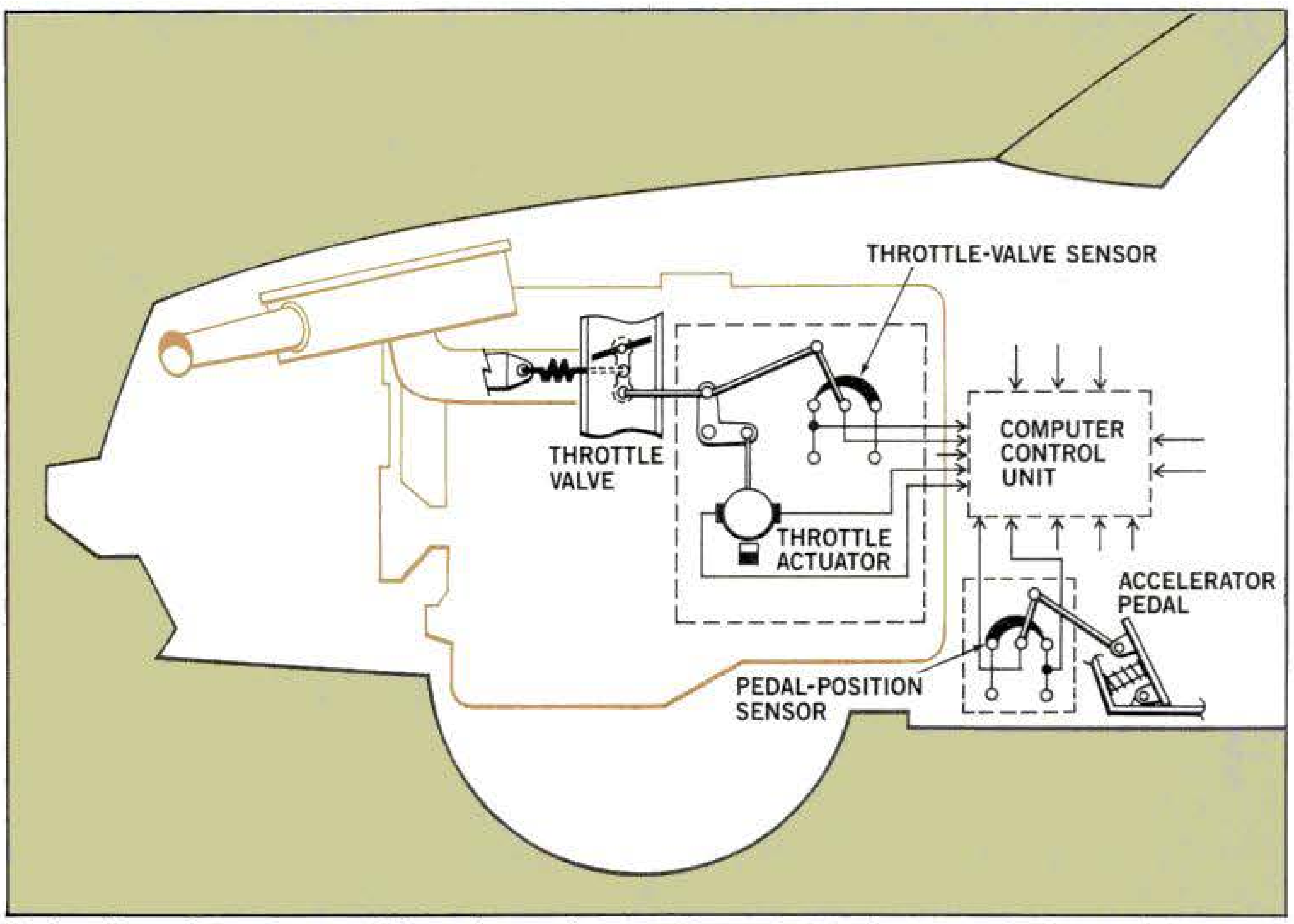
This is truly radar detection engineering at its finest. And Spectrum 2 is backed by an exclusive 3 year warranty. The most comprehensive ever.

For a free brochure or information on where to purchase Spectrum 2, call 1-800-531-0004. In Massachusetts call 1-617-692-3000.

SPECTRUM 2

Computerized gas pedal throttles wheelspin

A smart gas pedal equipped with its own computer is being developed to take over the job of familiar accelerator control cables in cars. The new device will also allow cruise control, speed and rpm limits, and automatic traction control to be programmed right in.



Drive-by-wire system (above) consists of a pedal-position sensor, throttle actuator, and computer control unit. As the pedal is depressed, the position sensor signals the actuator, via the computer, to open the throttle valve.

By TOM WILKINSON

Stamp on your car's gas pedal, and the accelerator control cable (you've seen it snaking out through the fire wall into the engine compartment) mechanically transmits your foot's motion to the throttle butterfly, thus revving the engine. Simple, right? Well, not simple enough to avoid being computerized. In a few years, say engineers from West Germany's Robert Bosch GmbH, the mechanical throttle linkage found in most motor vehicles will be replaced by an electronic system that consists of a gas-pedal-position sensor, a small computer, and a little electric motor to operate the throttle valve.

The first application of the drive-by-wire system, they say, will be on a West German bus, where it will replace a mechanical linkage that extends from one end of the bus to the other. A German passenger-car manufacturer is expected to install the system in a 1986 model, and Bosch believes U.S. auto makers will adopt it by the 1988 model year.

The concept is not totally new—fly-by-wire systems have been used on fighter aircraft. But in cars, is drive-by-wire a solution looking for a problem? Not really, because the new electronic accelerator system will be able to do more than merely avoid the friction and slop associated with today's mechanical throttle linkage.

Most important for car makers, it will make possible a simple but sophisticated electronic traction regulation system with the built-in ability to prevent wheels from spinning out of control on slippery roads and during too-fast accelerations. When wheel-rotation sensors—the same used by the new anti-lock braking systems [PS, Nov. '84]—monitor very rapid wheelspin, they alert the computer, which signals the motor to back off on the throttle until the wheels slow.

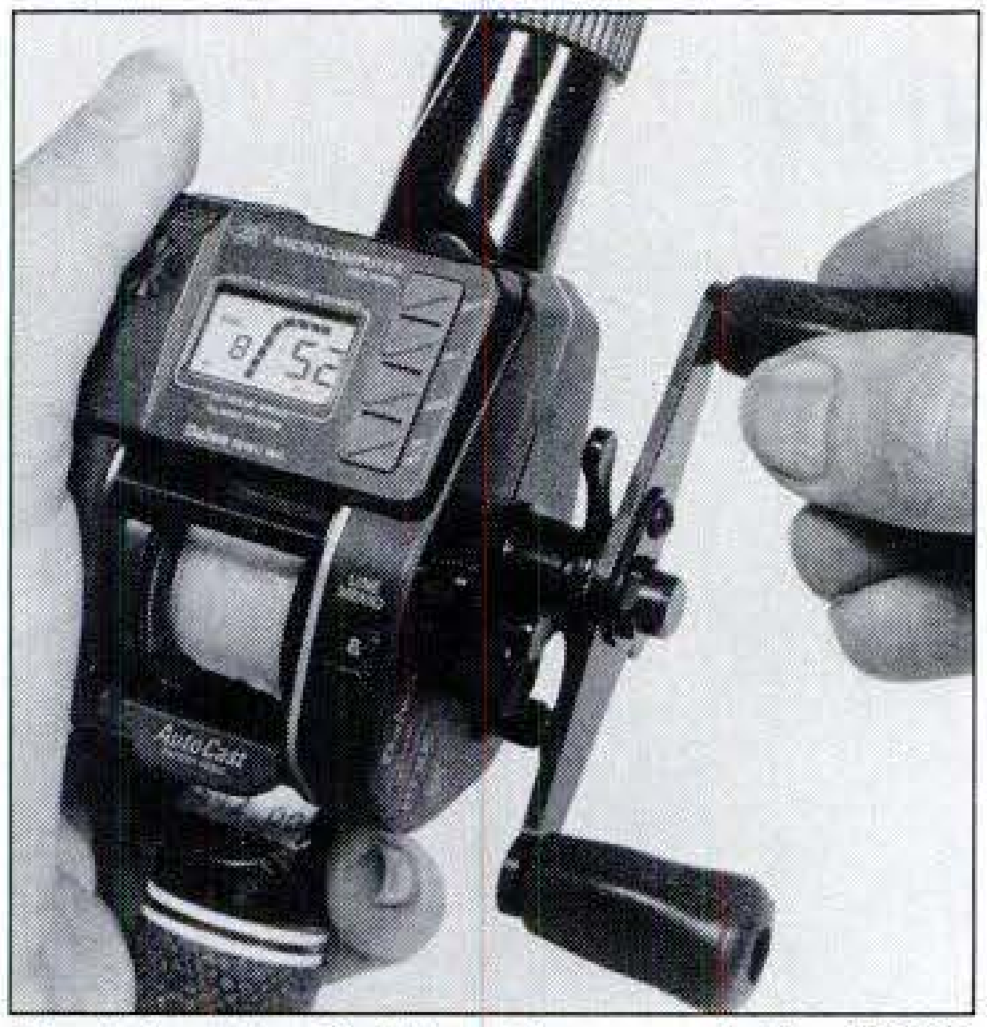
Bosch engineers consider it an economical alternative to costly four-wheel-drive systems. "For anti-spin, you need this feature," Karl-Heinz Volz, marketing manager of Bosch's Division 4, explains. "You must be able to override driver impulse."

Other new features made possible by the drive-by-wire system include

- A cruise-control mechanism built right into the accelerator electronics that would replace the current systems, which employ vacuum motors to actuate the throttle.
- Improved engine idle regulators that automatically compensate for the power drain of air conditioning and power steering systems, thus eliminating the need for throttle kickers—solenoids that speed up the idle so the load doesn't stall the engine.
- Engine warm-up controls that would replace electrical or vacuum motors that control the idle speed just after start-up.
- Integrated speed-regulation functions that protect the engine from excessive speeds, a task now often performed by interrupting fuel flow and ignition sparking.
- A fuel-saving device that would override "lead-foot" drivers who stomp on the gas pedal at every green light, by allowing the engine to attain peak power and then holding it.

There are three major parts to the system: 1) An accelerator pedal sensor that picks up the position of the pedal, which also has a kick-down sensor for downshifting into a passing gear and a spring that provides resistance to the pressure of a driver's foot. 2) A small electric motor that operates the throttle blade or control lever on a diesel fuel-injection pump. 3) A small computer that can be programmed to transmit movement directly to the throttle blade, or can modify the driver's commands based on information from other sensors in the vehicle.

Reel smart



Reel in the fishing line, and the LCD on Daiwa's PT10E reel shows a curved graph divided into nine bars. That means you're retrieving the line at a speed of nine ft. per sec. The numbers show the reel is loaded with eight-lb. line and the lure is 52 ft. out.

Fishing has always been an inexact science fraught with variables—questions like: How far am I casting? How deep is my lure? How far out did that last fish hit? Daiwa's computerized reel ["What's New," PS, Dec. '84] helps answer these questions and some you may not have thought of.

Tiny touch pads let you program the reel for line length and type. Every time you cast, the tiny computer counts the revolutions of the spool and calculates how much line you've thrown out. The distance—in feet—reads out on a liquid-crystal display atop the reel.

As you reel in, the distance display counts down, and your rate of retrieval is displayed—in feet per second—in a miniature bar graph. If you hook a good fish and it takes line, the reel keeps you posted on its distance from the boat, and even how fast it is running.

A beeper (optional) sounds once a second after you cast so you can accurately count how many seconds you let your lure sink. This helps you work your lure at a uniform depth. The alarm also beeps every time you crank in 10 feet of line; this feature enables you to monitor your speed without watching the LCD. In my tests the reel's electronics worked perfectly—that is, until the two silver-oxide batteries died. But the reel still functioned.

Will the reel ($189 in Sears' boating and fishing catalog) help you catch more fish? That depends on how well you use it.—*A. J. Hand*

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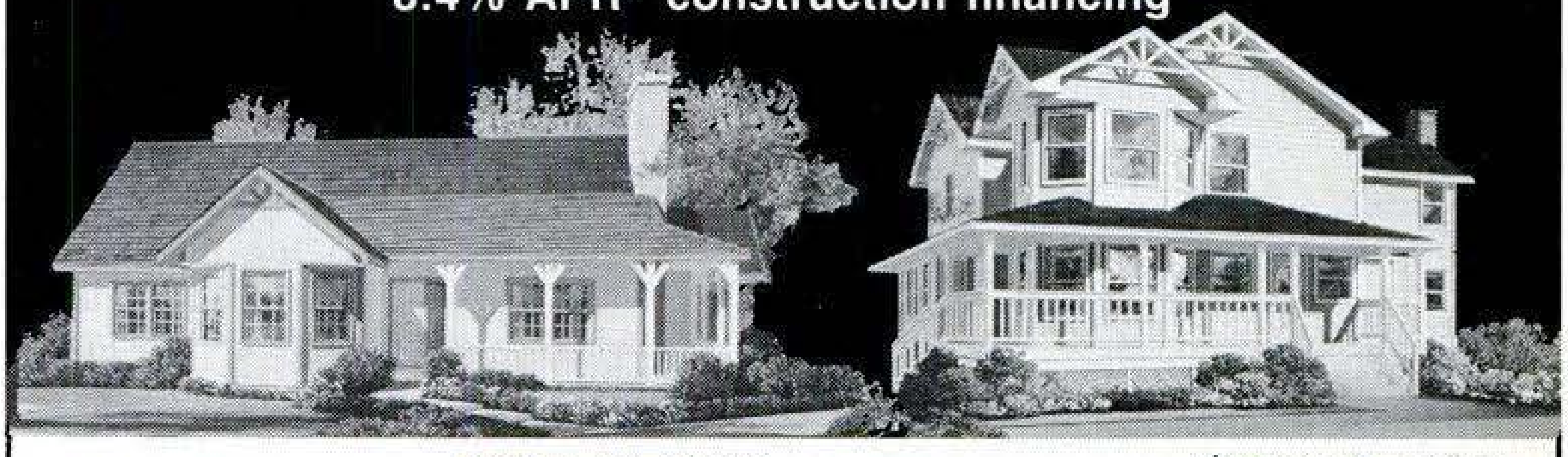

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Snap. An instant picture of me. But this one's not on film. It's captured in my personal computer, and I can save it on a disk, print it on paper, add it to a word-processing document, or even edit it on-screen before sending it to a friend via a modem. To do all that, I've been using one of the new low-cost (under-$500) video digitizers now available for a variety of computers, including the IBM PC, Commodore 64, and Apple IIe and Macintosh.

The typical video digitizer, such as the Magic digitizer (New Image Technology, 10300 Greenbelt Rd., Lanham-Seabrook, Md. 20706) shown above, is a box or circuit board that connects between a video camera (which is not usually included) and your computer. The digitizer receives a video image, converts it to binary data, and sends it to your computer. The whole picture-taking process is nearly automatic and takes from two to 20 seconds, depending on the system.

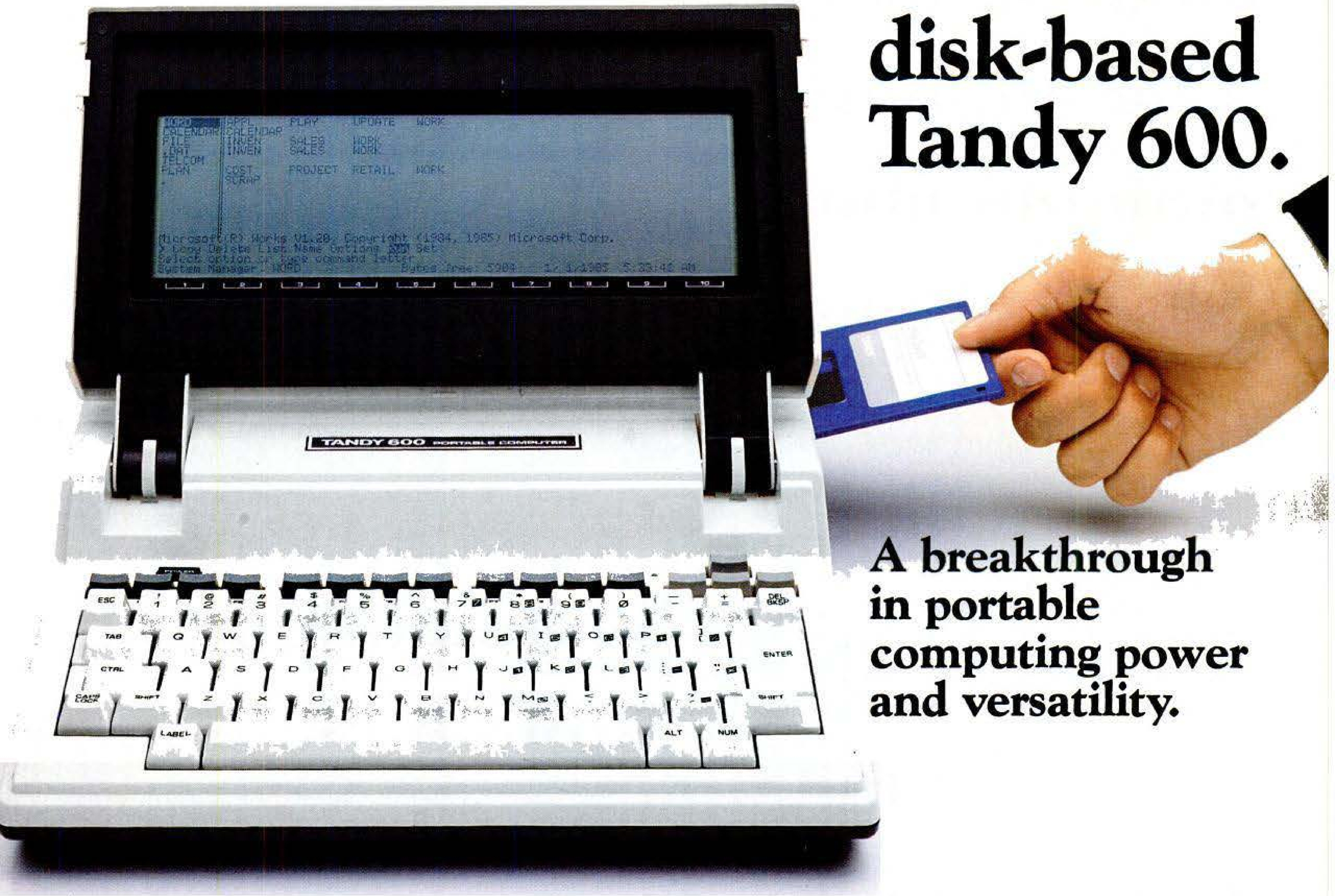
All low-cost digitizers produce black-and-white pictures only, even if you use a color camera and a computer capable of producing color. The resolution of the digitized image depends, first, on the camera and its lens: The better they are, the sharper the picture. The resolution also depends on the computer. For example, the Apple IIe, which has a maximum screen resolution of 280 by 192 picture elements (pixels), can't deliver the same sharp pictures as its cousin Macintosh, which has a maximum resolution of 512 by 342 pixels.

Once you've taken a picture with a digitizer, what do you use it for? Making computer portraits is one application. Snap a picture of the family, and use your computer to print this year's Christmas cards. Don't like the portrait? Shoot again or edit it. Once the digitized image is in the computer, you can easily retouch it by using a paint program such as PC Paint (for the IBM PC) or MacPaint (for the Macintosh).

For more serious work, many word-processing programs let you combine text with pictures. Don't describe the new mousetrap you've just invented —take a picture of it, and "paste" it into the document. Or use the digitizer as an inexpensive facsimile device. Take a snapshot of a drawing or photograph, and with the help of a modem and telecommunications program, send the digitized picture to a colleague via phone line. Once the picture is received on the other end it can be viewed on screen, printed, or even revised and sent back to you for approval. The transmission is usually far less costly—and far faster—than an overnight delivery service.

Finally, one application is open to your imagination. Most digitizers can accept a signal from any standard video source. That means you can digitize pictures from your VCR or videodisc player.—*Gordon McComb*

The new disk-based Tandy 600.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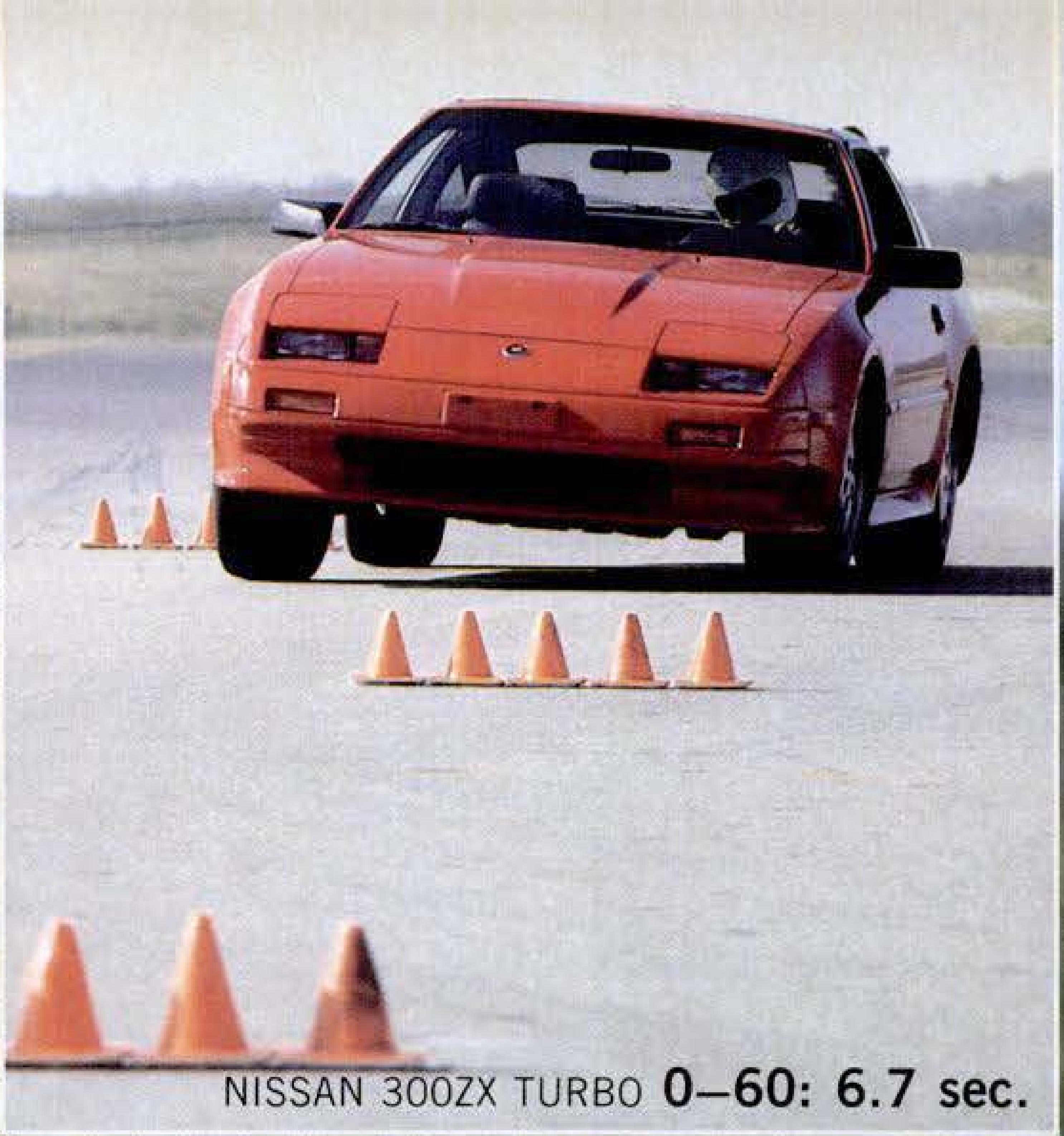
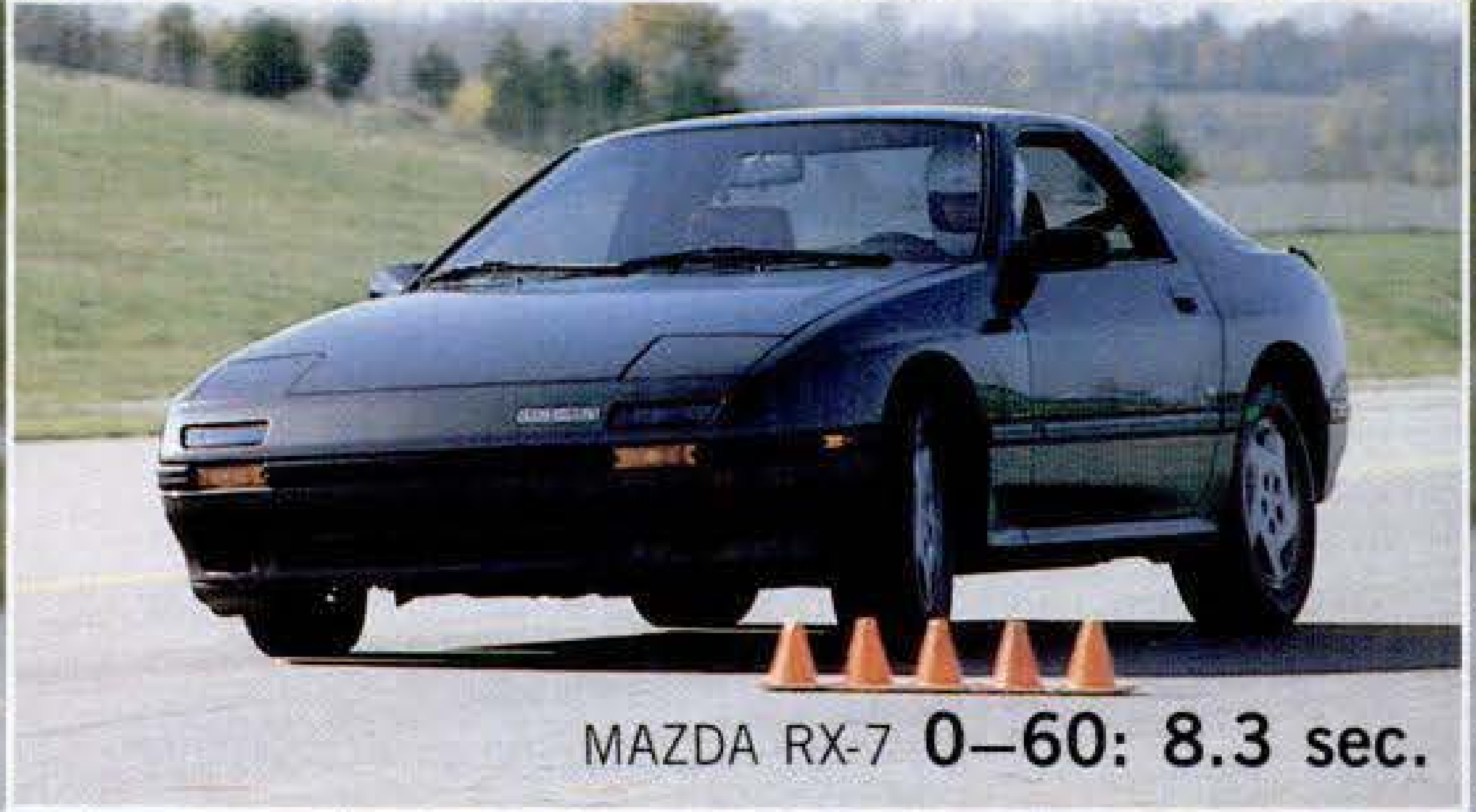
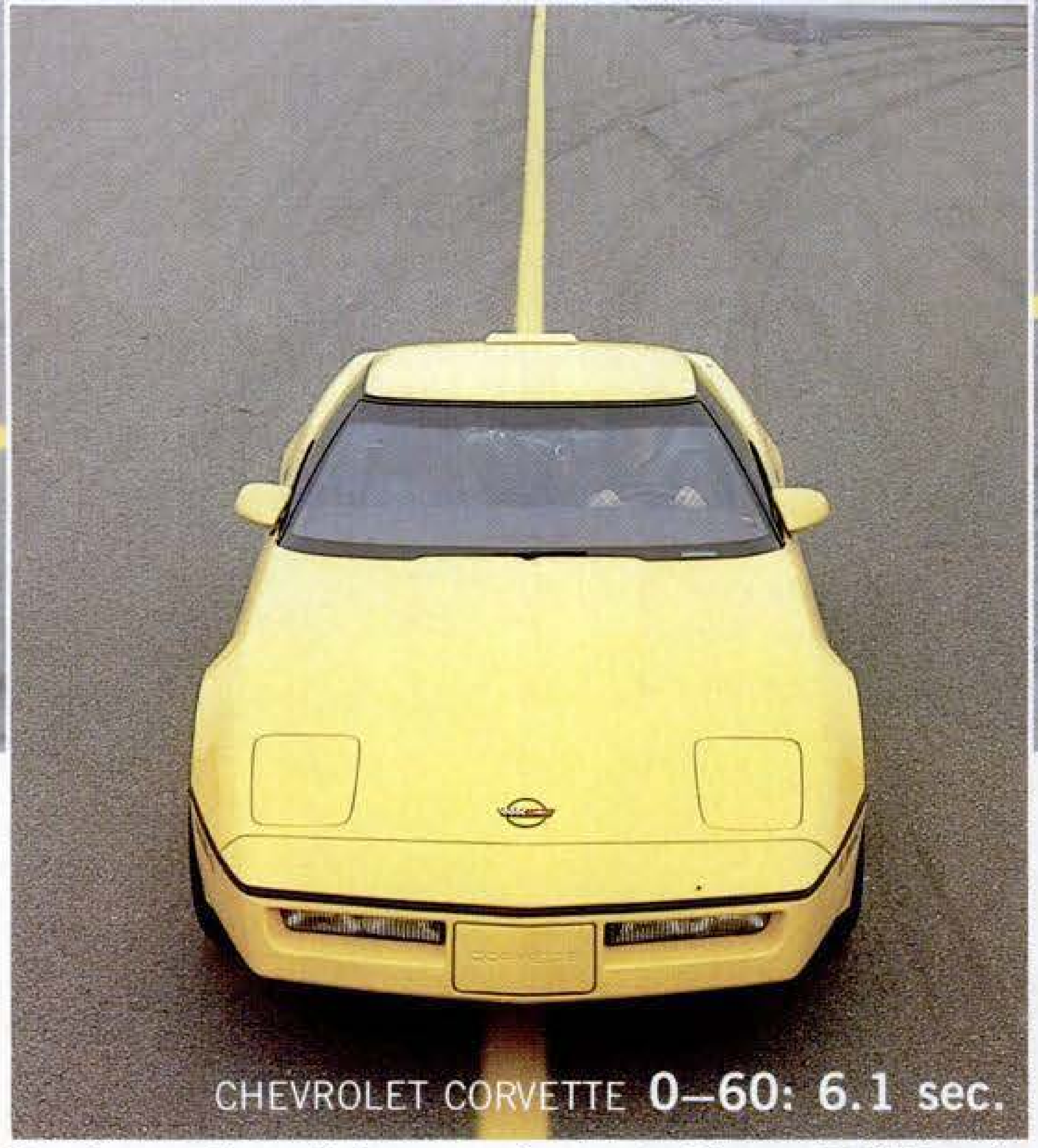
HOT


NISSAN 300ZX TURBO **0–60: 6.7 sec.**


MAZDA RX-7 **0–60: 8.3 sec.**


CHEVROLET CORVETTE **0–60: 6.1 sec.**

PORSCHE 944 TURBO **0–60: 5.9 sec.**

Road munchers (left top to bottom): Nissan 300ZX turbo surges through the low-speed test. Mazda RX-7 also swivels through the low-speed grid. Chevrolet Corvette lines up for a 6-sec. blast to 60 mph. Porsche 944 turbo (above right) uses 142 ft. of brake lane for its first 60-to-0-mph stop. (The time below each vehicle is its single fastest run.)

These are the Olympic athletes of autodom. As a group they run faster, stop shorter, and handle better than anything PS has ever tested. Chevrolet Corvette, Porsche 944 turbo, Nissan 300ZX turbo, and the new Mazda RX-7 blew through our acceleration, braking, and handling tests as if they were out for a Sunday ride. In the process they shattered several high-performance records.

POPULAR SCIENCE CAR TEST #204
Total cars tested to date: 736

PERFORMERS

By JACK KEEBLER
Photos by Greg Sharko

"You've missed the point. We're not in the car business. We're actually in the entertainment business." That's what Ferdinand Porsche told one reporter trying to fathom the special appeal of his sports cars. And if you've never fully understood sports cars, perhaps that enigmatic statement sheds some light on the group Popular Science tested this month.

On a cool morning late last year the PS crew was entertained for several hours on a windy taxiway at Stewart Airport in Newburgh, N.Y. We then took the cars on the road to learn what they're like to use every day.

The cars showcase a variety of engine technologies: a rotary, a turbocharged four and V6, and a fuel-injection V8. The chassis also reflect different engineering approaches. The result is a group of performers, each with a unique personality.

Although the 1986 RX-7 is all new, Mazda chose to install essentially the same 13B fuel-injection rotary used in last year's RX-7 GSL-SE. Its excellent responsiveness and characteristic snarl provide an exciting backdrop to every up or down shift. And although the RX-7 brought up the rear in our acceleration tests, it could hardly be described as slow. Still, in the rarefied atmosphere of six-second zero-to-60-mph times, its eight-second

Continued

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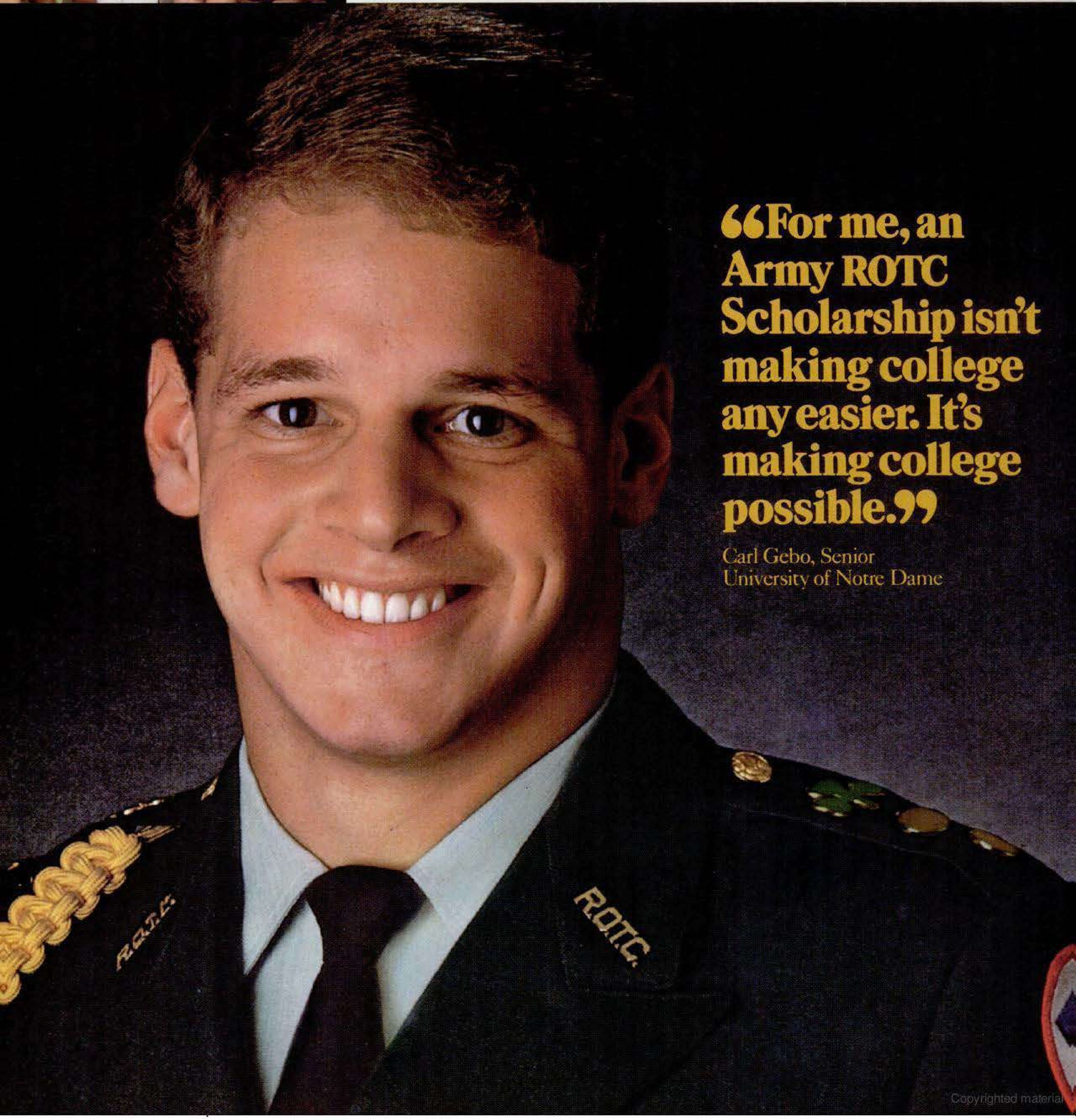


“For me, an Army ROTC Scholarship isn't making college any easier. It's making college possible.”

Carl Gebo, Senior
University of Notre Dame

sprints paled. Mazda says we'll have to wait until mid-year for a quicker turbocharged version. (The zero-to-60-mph times in the PS test results represent an average of two runs.)

The three-liter V6 in the Nissan 300ZX is a paragon of smoothness and quiet. In fact, this engine is so refined that Nissan uses the same six-cylinder (without turbo) in the Maxima—its flagship luxury sedan. But the 300ZX's engine does have a flaw: It is heat sensitive. As the Nissan V6 gets hot, performance drops off. The 300ZX ran its quickest zero-to-60-mph time on its first run, a sizzling 6.7 seconds. Its fourth and final run to 60 took 7.65 seconds, almost a full second difference. Nissan should consider either an intercooler or a revision in the underhood layout to prevent the problem.

With the Corvette's 350-cu.-in. V8, eyeball-flattening torque is just a toe tap away in any gear. Unlike most sports-car engines, which tend to be peaky, the fuel-injection 350 packs a Rocky Balboa-style wallop of torque, even down to 2,000 rpm. To handle that power, Chevy installs a special four-speed manual transmission. A button on top of the shift handle lets you activate an overdrive gear when second, third, or fourth gear is selected. The only real problem with this transmission is a tremendous amount of gear whine. I also have a minor quibble with the shifter. It sounded and felt like a broomstick handle in an empty bucket.

It's hard to believe that the 944 turbo has only a four-cylinder under the hood. The 2.5-liter power plant, which makes better than 200 horsepower, suffers none of the peakiness or throttle lag usually associated with small turbocharged engines. Not quite as torquey as the Chevy V8, this four still displays an unexpected bounty of low-rpm elasticity.

Transferring the power to the ground is a five-speed transaxle located between the rear wheels. Using this gearbox's excellent shifter is a bench-mark experience for anyone familiar with the wide-ranging shift quality in manual transmissions with sporting pretensions. Another pleasant surprise is the lightness of the clutch. The 944 clutch also was impressive during our acceleration runs. I found that low-rpm clutch drops produced a prodigious amount of wheel hop and slow times, so I finally

Continued

POPULAR SCIENCE TEST RESULTS

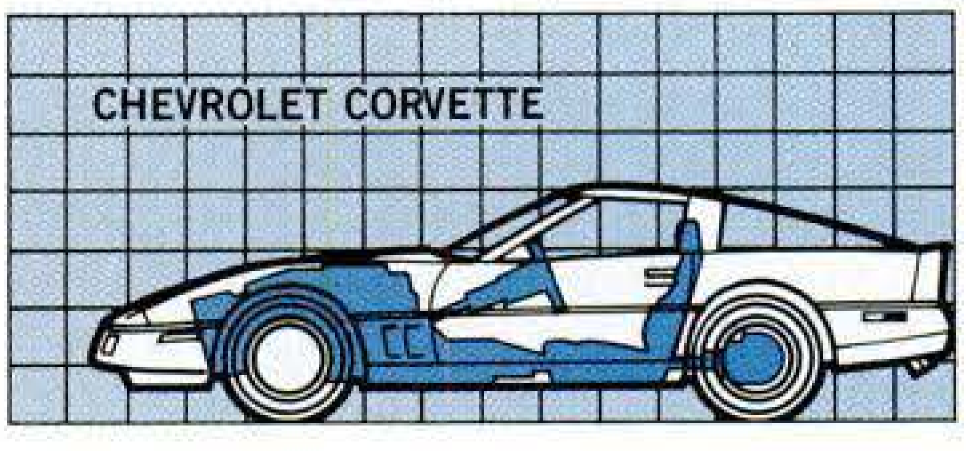
TEST RESULTS	Chevrolet Corvette	Mazda RX-7	Nissan 300ZX turbo	Porsche 944 turbo
Acceleration (sec.)				
0–30 mph	2.10	2.84	2.41	2.13
0–40 mph	3.25	4.20	3.87	3.24
0–50 mph	4.63	6.21	5.43	4.58
0–60 mph	6.26	8.46	6.96	5.95
Brake test (cool) 60–0 mph				
Stopping distance (ft.)	141	167	126	142
Pedal pressure (lbs.)	120	40	20	140
Brake test (hot) 60–0 mph				
Stopping distance (ft.)	127	154	174	167
Pedal pressure (lbs.)	125	30	75	110
Interior noise @ 60 mph (dBA)	71	72	68	69
Handling test (mph)	72.7	72.7	70.0	71.2
Maneuverability test (mph)	32.4	33.6	32.4	33.0
EPA FUEL MILEAGE (mpg)				
Highway	24	24	25	27
City	17	17	18	19
Calif. city	—	—	17	19

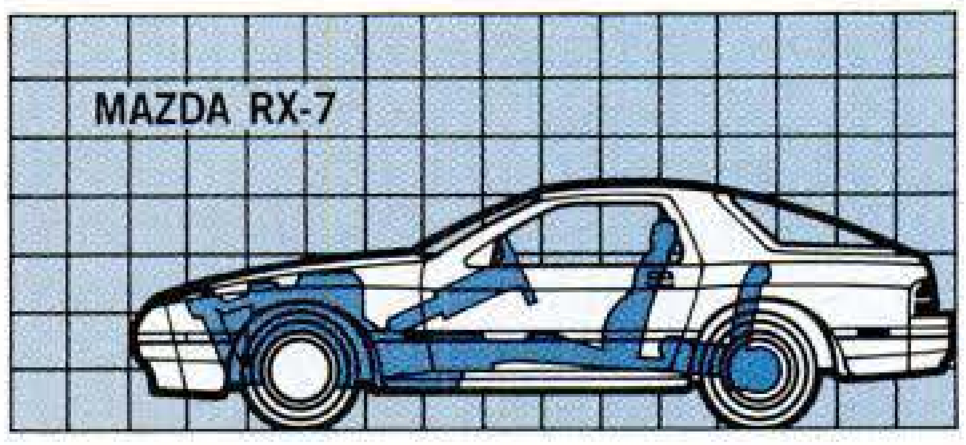
TEST CONDITIONS Ambient temperature, 45° F; relative humidity, 91%; barometric pressure, 29.79 in. Hg

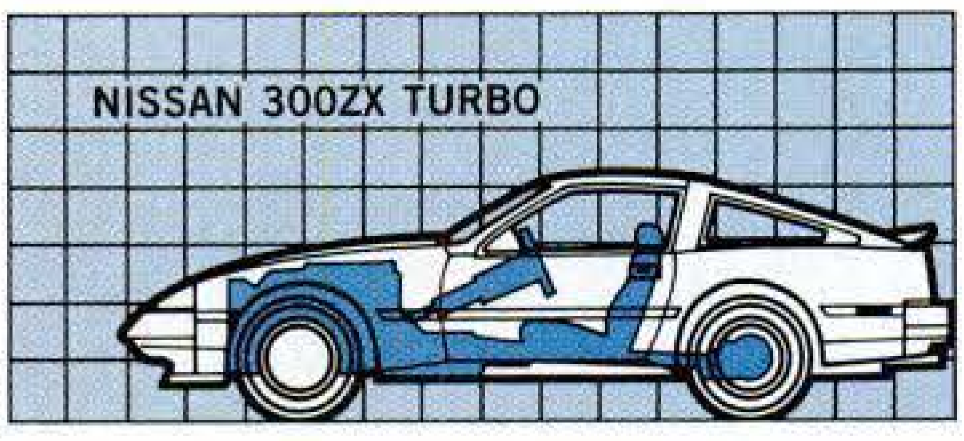
Dimensions and specs

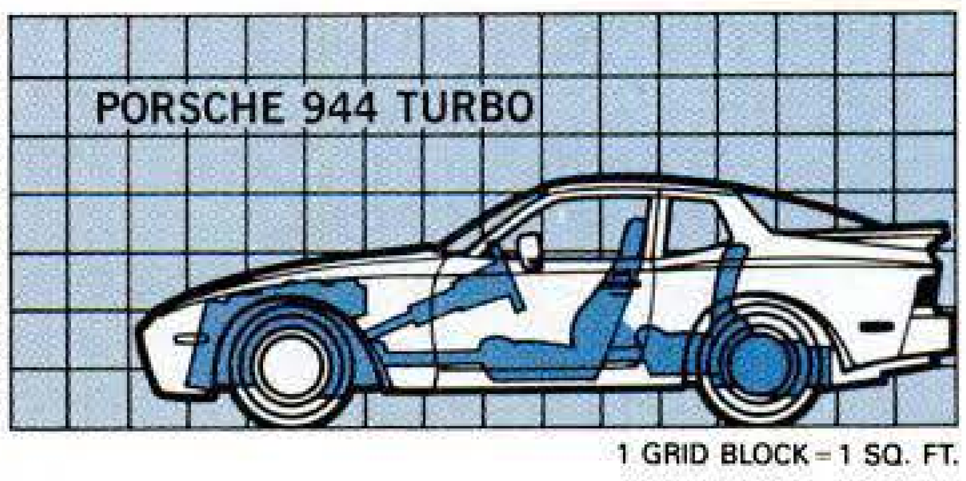
DIMENSIONS (inches)	Chevrolet Corvette	Mazda RX-7	Nissan 300ZX turbo	Porsche 944 turbo
Wheelbase	96.2	95.7	91.3	94.5
Overall length	176.5	168.9	170.7	168.9
Overall height	46.4	49.8	51.0	50.2
Overall width	71.0	66.5	67.9	68.3
Track, F/R	59.6/60.4	57.1/56.7	56.5/57.3	58.2/57.1
Ground clearance	4.7	5.1	5.9	4.7
Front head room	36.5	37.2	36.6	35.8
Front hip room	49.3	52.4	40.0	42.0
Front leg room	42.6	46.9	43.6	47.0
SPECIFICATIONS				
Engine type	V8	Rotary	V6 turbo	In-line 4
Displacement (cu. in./L)	350.0/5.7	80.0/1.3	180.6/2.96	151.0/2.5
Compression ratio	9.5:1	9.4:1	7.8:1	8.0:1
Carburetion	E.F.I.	E.F.I.	E.F.I.	E.F.I.
Net hp @ rpm	230 @ 4,000	146 @ 6,500	200 @ 5,200	217 @ 5,800
Net torque (ft.-lbs.) @ rpm	330 @ 3,200	138 @ 3,500	227 @ 3,600	243 @ 3,500
Transmission	4-speed overdrive	5-speed manual	5-speed manual	5-speed manual
Axle ratio	3.07:1	4.10:1	3.545:1	3.375:1
Tire make	Goodyear	Bridgestone	Bridgestone	Pirelli
Tire type	Eagle VR 50	Potenza RE 71	Potenza RE 91	Cinturato P7
Tire size	P255/60VR16	205/60VR15	225/50VR16	205/55VR16(front) 225/50VR16(rear)
Steering	Power, rack and pinion	Power, rack and pinion	Power, rack and pinion	Power, rack and pinion
Overall steering ratio	13.0:1	15.2:1	17.0:1	—
Turns, lock to lock	1.96	2.70	2.80	3.24
Turn diameter (ft.)	40.4	16.1	32.2	33.8
Front suspension	Independent, short and long A-arms, transverse mono-leaf	Independent, MacPherson strut, coil springs, anti-roll bar	Independent, MacPherson strut, coil springs	Independent, coil/shock absorber struts
Rear suspension	Independent, five-link, forged aluminum control arms, transverse mono-leaf	Independent, Tri-axial floating hubs, trailing arms, coil springs, anti-roll bar	Independent, trailing arms, coil springs	Independent, trailing diagonal arm, torsion bar
Front stabilizer-bar diameter (in.)	1.20	0.87	0.91	0.89
Rear stabilizer-bar diameter (in.)	0.87	0.47	0.87	0.71
Brakes	Disc-disc	Disc-disc	Disc-disc	Disc-disc
Brake swept area (sq. in.)	—	418.0	340.1	344.0
Fuel tank (gal.)	20.0	16.6	19.0	21.1
Trunk space (cu. ft.)	17.9	19.5	15.3	20.7
Liftover height (in.)	35.5	36.5	32.6	35.4
Curb weight (lbs.)	3,234	2,625	3,267	2,899
F/R weight distribution (%)	50/50	51/49	51/49	50/50
Base price	$27,027	$11,995	$20,099	$29,500
Price as tested	$29,692[1]	$12,995[2]	$22,449[3]	$29,500

Major options (over $100) [1]Delco/GM/Bose music system $895, Z51 handling package $470, graphite leather seats $400, six-way seat $225, speed control $185, power locks $175, defogging system $165, electronic air conditioning $150; [2]sport package/sport tuned suspension $1,000; [3]leather/electronics package $2,350









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settled on slipping the clutch at a 5,500-rpm engine speed. This produced rocket fast launches with virtually no wheel hop. Surprisingly, the clutch seemed no worse for the extra abuse, despite its low-effort feel.

Ultimate handling

It took less than a mile at the wheel of the new RX-7 to realize that the new car's suspension is more communicative than the old. There's more precision to the way the car tracks on the highway and chops through curves.

PS ratings—test report in a nutshell

The ratings are based on test results and measurements. Results should be read with the understanding that they reflect tests only on our sample cars. An excellent rating is 5 points; very good, 4; good, 3; fair, 2; poor, 1; very poor, 0.

	Chevrolet Corvette	Mazda RX-7	Nissan 300ZX turbo	Porsche 944 turbo
Acceleration	5	5	5	5
Braking	4	3	2	2
Handling	5	5	5	5
Maneuverability	5	5	5	5
Quietness	0	0	2	1
Roominess	0	0	0	0
Vision	3	4	4	5
Entry/exit ease	0	0	0	0
EPA economy	2	2	3	3
Ride comfort*	0	1	3	1

*Author's opinion

PS serviceability ratings

How easy is it to service these cars? To give you an approximation of how difficult it is for a typical person to perform various service operations, we examine each test vehicle. The numbers mean: 1, very difficult; 2, difficult; 3, average degree of difficulty; 4, easy; 5, very easy.

	Chevrolet Corvette	Mazda RX-7	Nissan 300ZX turbo	Porsche 944 turbo
Checking fluid levels				
Battery	5	5	5	5
Master cylinder	5	5	5	5
Windshield washer	5	5	5	5
Engine oil	5	5	5	5
Coolant	5	5	5	5
Checking the engine				
Spark plugs	3	3	3	5
Distributor	3	—	5	5
Oil filter	3	5	4	5
Oil fill	3	5	5	5
Air filter	2	2	2	2
Replacing hoses				
Upper radiator hose	2	5	5	3
Lower radiator hose	4	4	4	3
Heater hoses	2	4	3	2
Changing bulbs				
Headlights	5	3	2	3
Taillights	3	5	4	4
Front running lights	5	3	3	3
Front parking lights	5	3	3	3
Front directionals	5	3	3	3
Rear directionals	5	5	4	4
Rear running lights	—	5	3	4
Checking fuses	5	3	3	5
Spare-tire accessibility	2	5	5	5
Changing belts	5	3	3	1

Much of this handling magic is provided by the rear axle's Triaxial Floating Hubs. These hubs allow limited amounts of both toe-out and toe-in, or *steer*, during high-speed maneuvers, hard acceleration, and quick braking. For example, as the car cuts hard into a curve, the outside rear wheel turns in toward the curve's apex. It sounds strange—but it works. Note that the Mazda tied with the Corvette for top honors in the high-speed lane-change maneuver, and it did so on the skinniest tire footprint in the group (see spec table).

Like German sedans, the RX-7 feels too firm at first. But like the Teutonic hardware it copies so well, the faster you go the better the ride feels. One debit in the Mazda's column is interior noisiness. The no-frills model we tested seemed to have little sound-deadening features.

On the track the big yellow Corvette handled like a go-cart. I found that even the smallest steering inputs produced instant—and exaggerated—results. In fact, during a particularly violent sneeze on the New York State Thruway, I twitched the steering wheel and the Chevrolet nearly switched lanes.

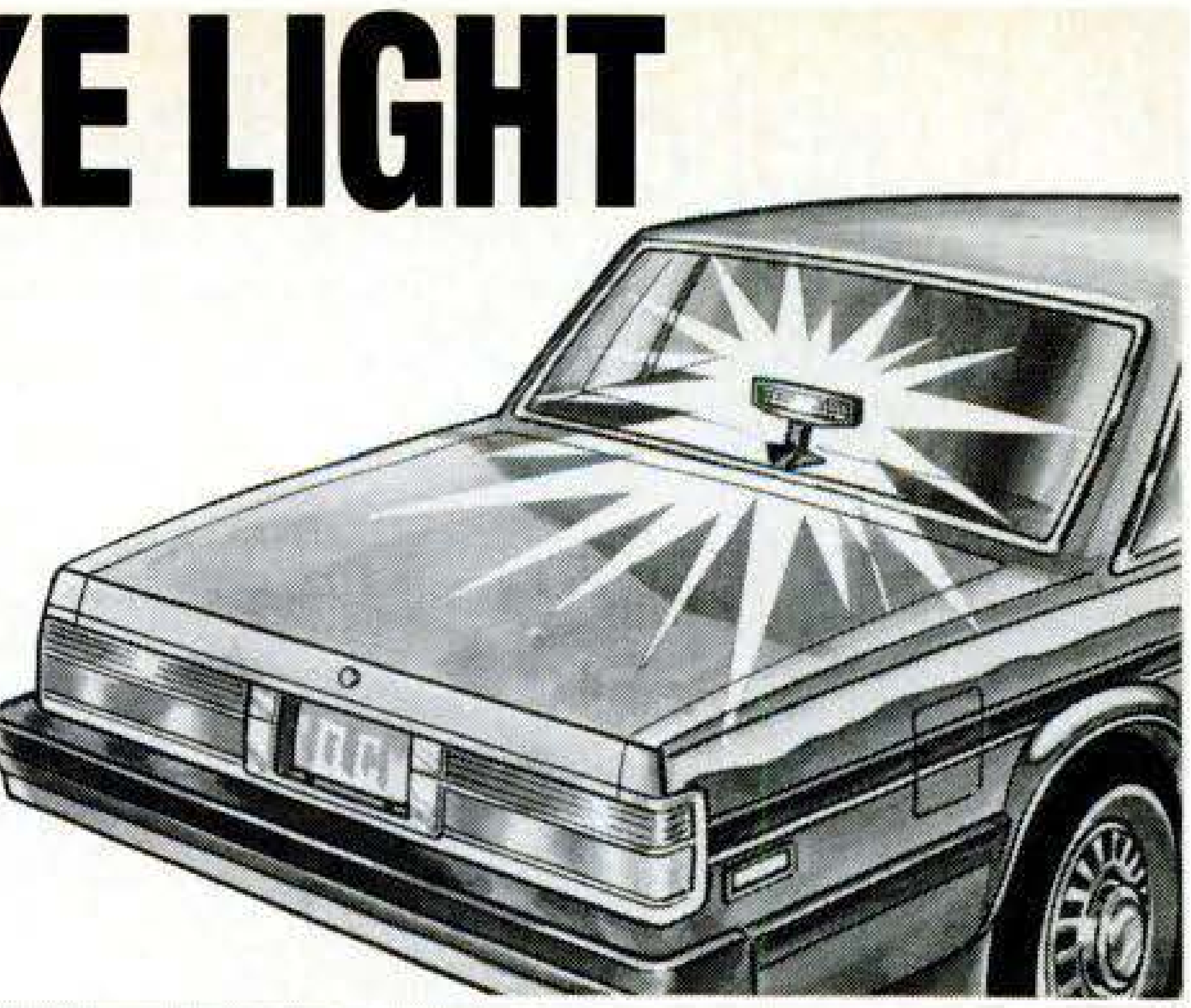
On the billiard-table-smooth track Corvette performs brilliantly. But the wonderful handling stiffness of this car actually becomes a kidney-jiggling handicap on rough roads. Chevy does manage to soften the road blows somewhat with a pair of cushy bucket seats. And if the car still handled well on uneven pavement, I could probably forgive the harsh ride. But the stiffness of the suspension prevents the tires from settling into road irregularities. Result: On rough corners the car skips to the edge of the road like a flat stone tossed across the surface of a lake.

The 300ZX was the slowest in the high-speed handling grid, and tied for last slot in the low-speed handling test. But this is one of those cases in which the raw data doesn't tell everything about the car's personality. Unlike the other cars in this group, the 300ZX does not sacrifice ride for ultimate handling. The Nissan suspension provided smooth cruising on the highway and positively gobbled up New York City potholes. In addition, I noticed very low interior sound levels in the ZX. In fact, the 68-dBA reading was so low that I ran the sound check twice.

Porsche has never been accused of building soft-riding sedans. And that reputation for tautness remains intact with the 944 turbo. Like the builders

Continued

New! EYE-LEVEL BRAKE LIGHT Gives YOUR CAR 1986 STYLING and SAFETY!



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Astonishing Fact: Estimates by the NHTSA predict that the eye-level third brake light will **prevent 40,000 personal injuries** a year.

Astonishing Fact: Use of the eye-level third brake light can reduce vehicle damage and repairs by almost 60%.

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Federal Safety Regulations Now Require Eye-Level-Mount Brake Lights On All 1986 Model Cars.

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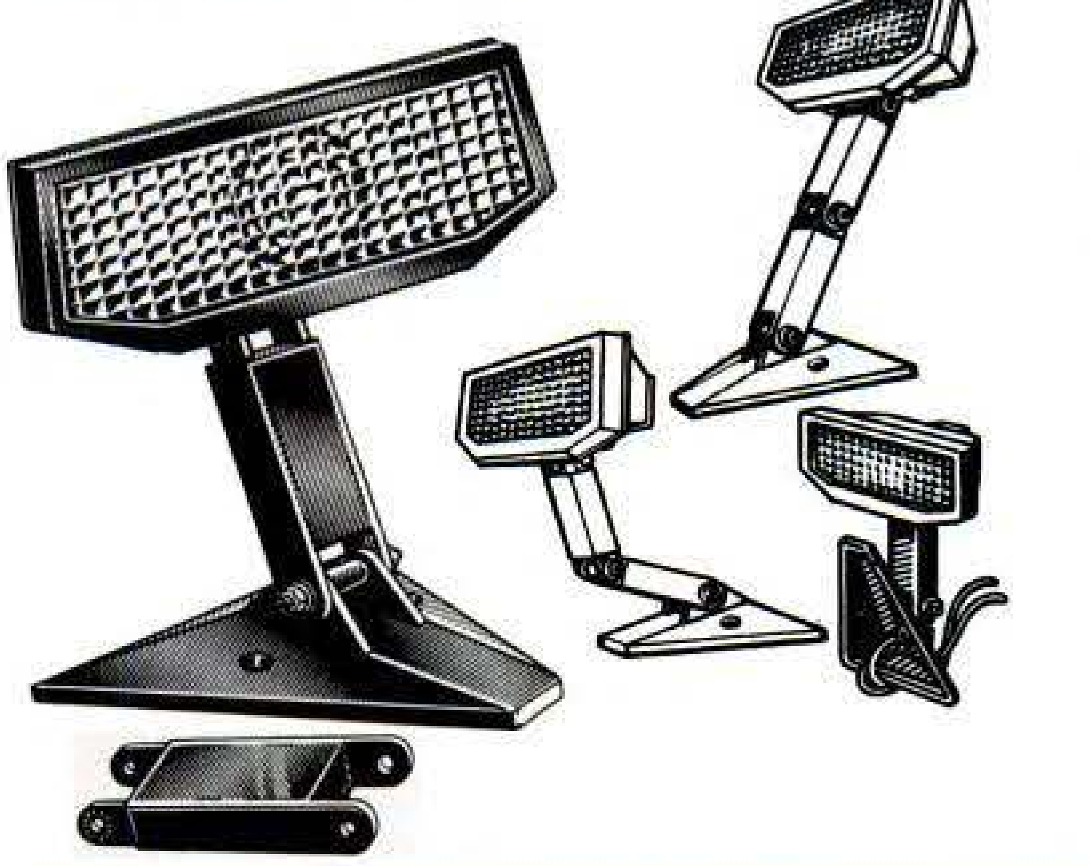

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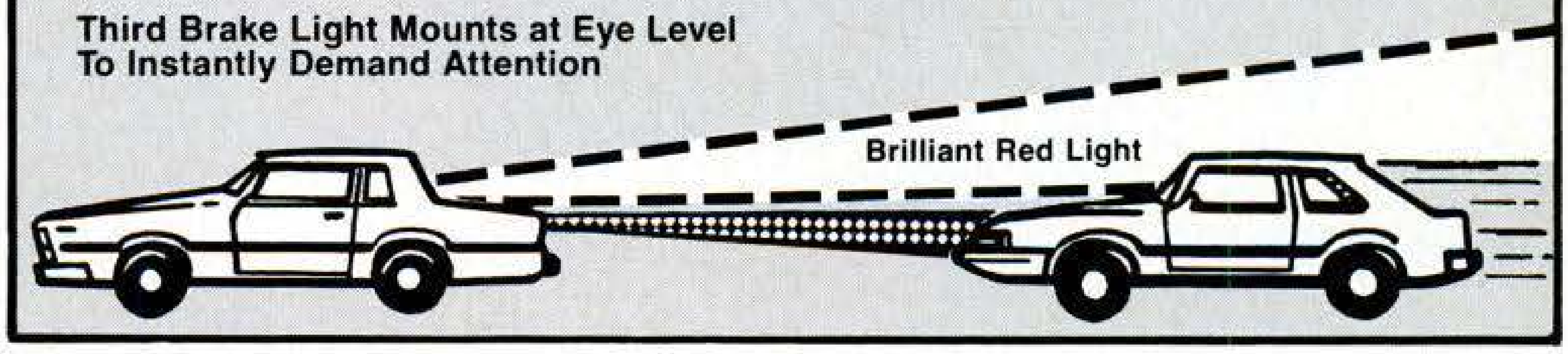
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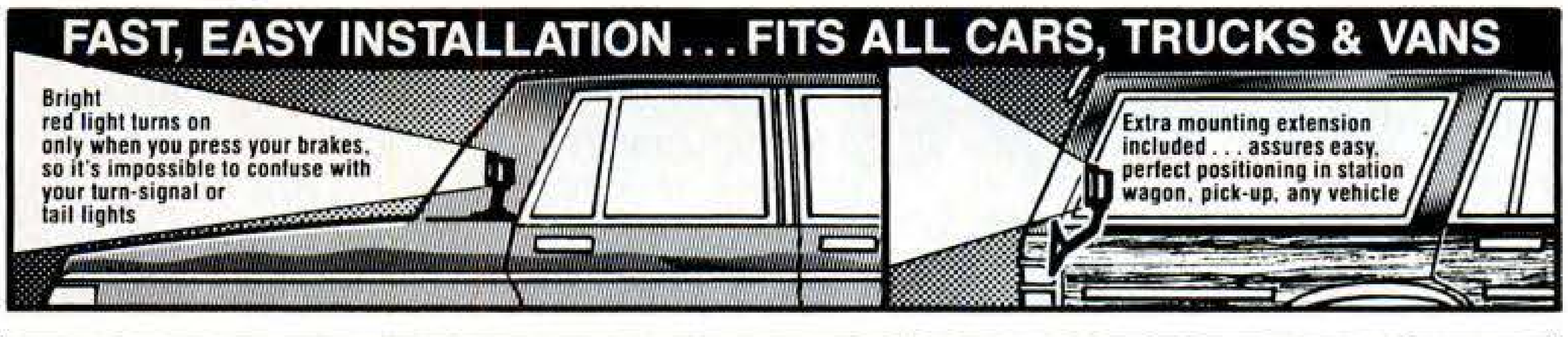

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Hot performers

Continued

of the Corvette, Stuttgart partially offsets the car's harsh ride with a pair of soft buckets. Porsche placed third in the high-speed handling test and second on the low-speed maneuverability grid. Its steering is light, yet provides plenty of road feel and flawless accuracy. There are no handling quirks, even when the 944 is taken to the outer edge of good sense and tire adhesion.

Stopping power

I think that the RX-7's longish stops were more a function of brake-pedal numbness than lack of tire or brake-pad bite. During the final stop there was plenty of grip left in both the tires and calipers. With more practice, I'm sure I could have shortened the RX-7's stopping distances severely. (Note that the RX-7's hot stop after 12 stops from 60 mph was 154 feet. That's 13 feet shorter than its first stop.)

The 300ZX's stopping distances were surprising for two reasons: its dazzlingly short cold stop and its disappointingly long hot stop. Considering the Nissan's high curb weight, the 126-foot cold stop was a pleasant surprise. I did notice, however, gradually rising pedal pressure during our warm-up stops. In fact, the last warm-up stop took twice as much pedal pressure as the first. Clearly, the engine compartment is not the only area with a heat-buildup problem.

After examining the 944's large vented discs and finned brake calipers the night before the test, I predicted that the Porsche and Corvette would be the best stoppers. In the Porsche's case, looks are slightly deceiving. The first stop was 142 feet—not bad. But as with the 300ZX, I noticed steadily increasing pedal pressure during the warm-up stops. Later, I learned that the 944's pads were heavily glazed from hard stopping during a press demonstration. Time prevented Porsche from replacing them before our test, and this may have resulted in the below-par performance.

Without question the most impressive brakes in the contest were those on the Corvette. This year Chevy added a Bosch anti-lock system to the car's already impressive stopping system [PS, Nov. '85]. The 127-foot hot stop conveys some sense of how good this braking system is. But anti-lock does far more than reduce stopping distances. One of the most important things it does is to virtually eliminate the possibility of a skid or spin. Every stop is brake-lane or fast-lane dead center in any kind of weather.

Author's choice

Price + performance = RX-7. PS

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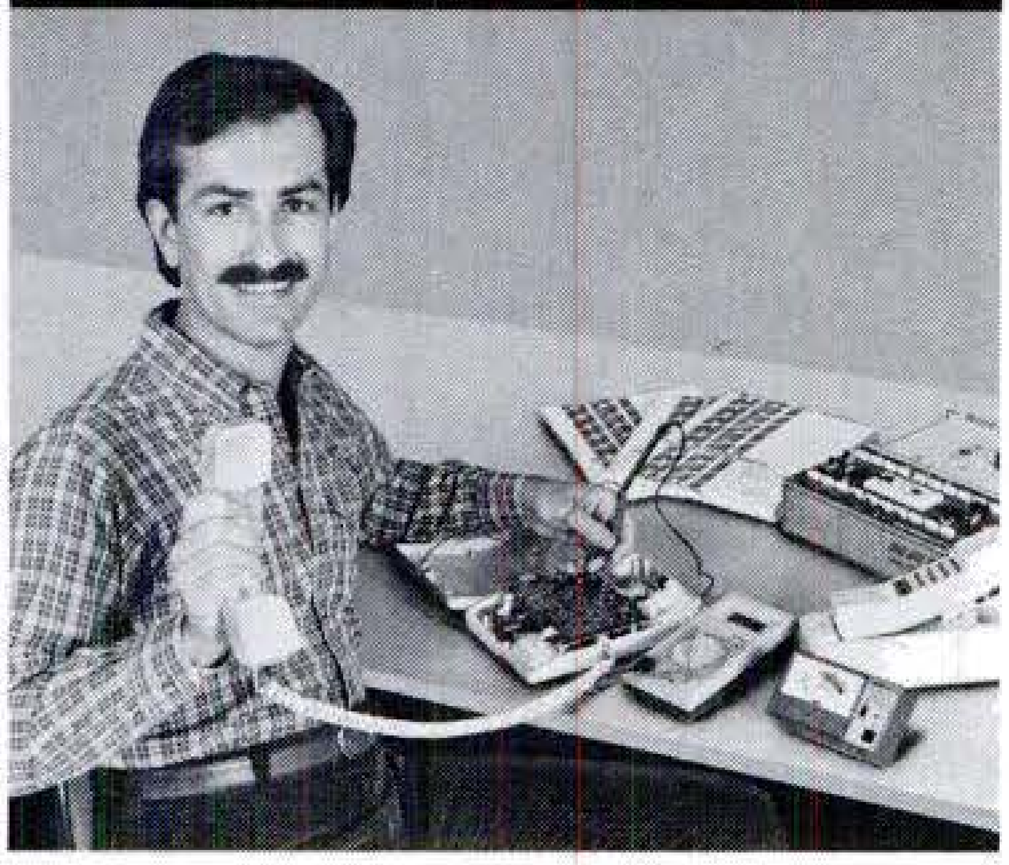

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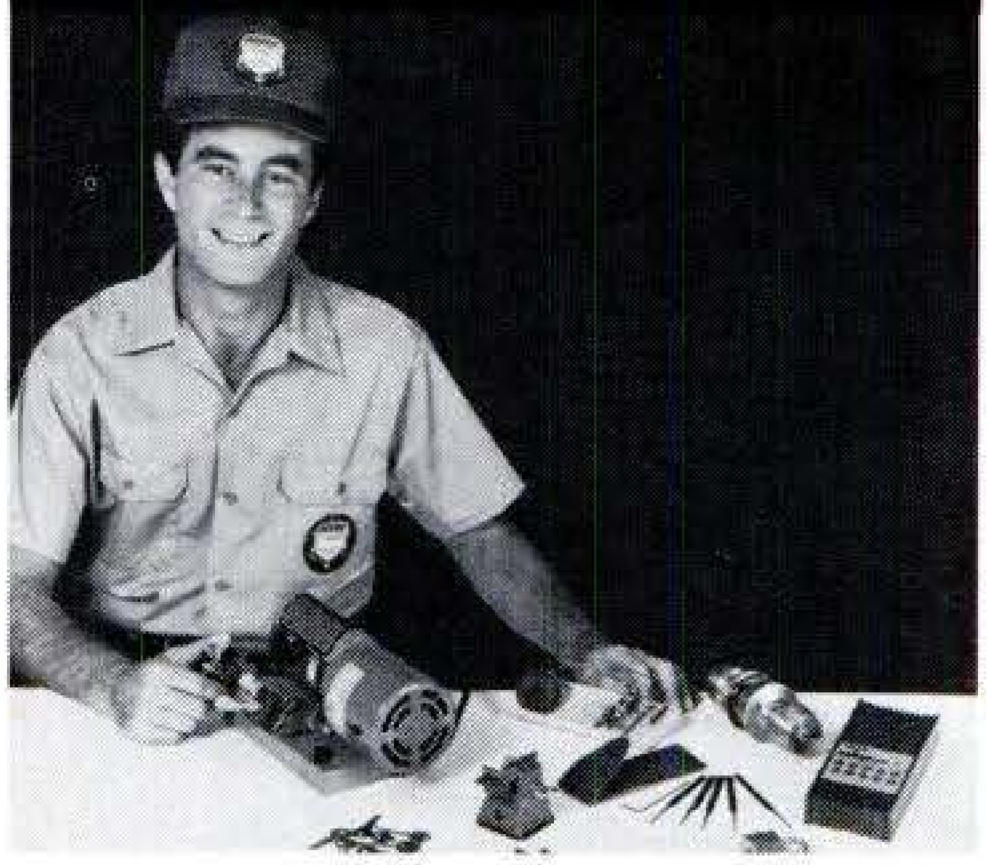

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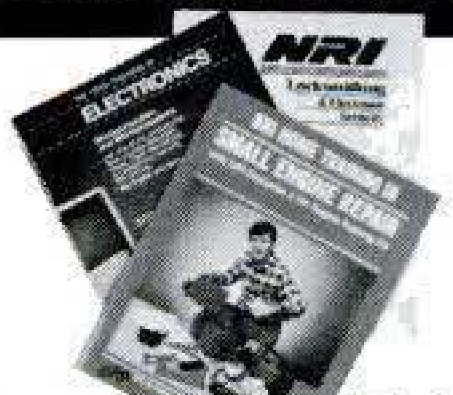

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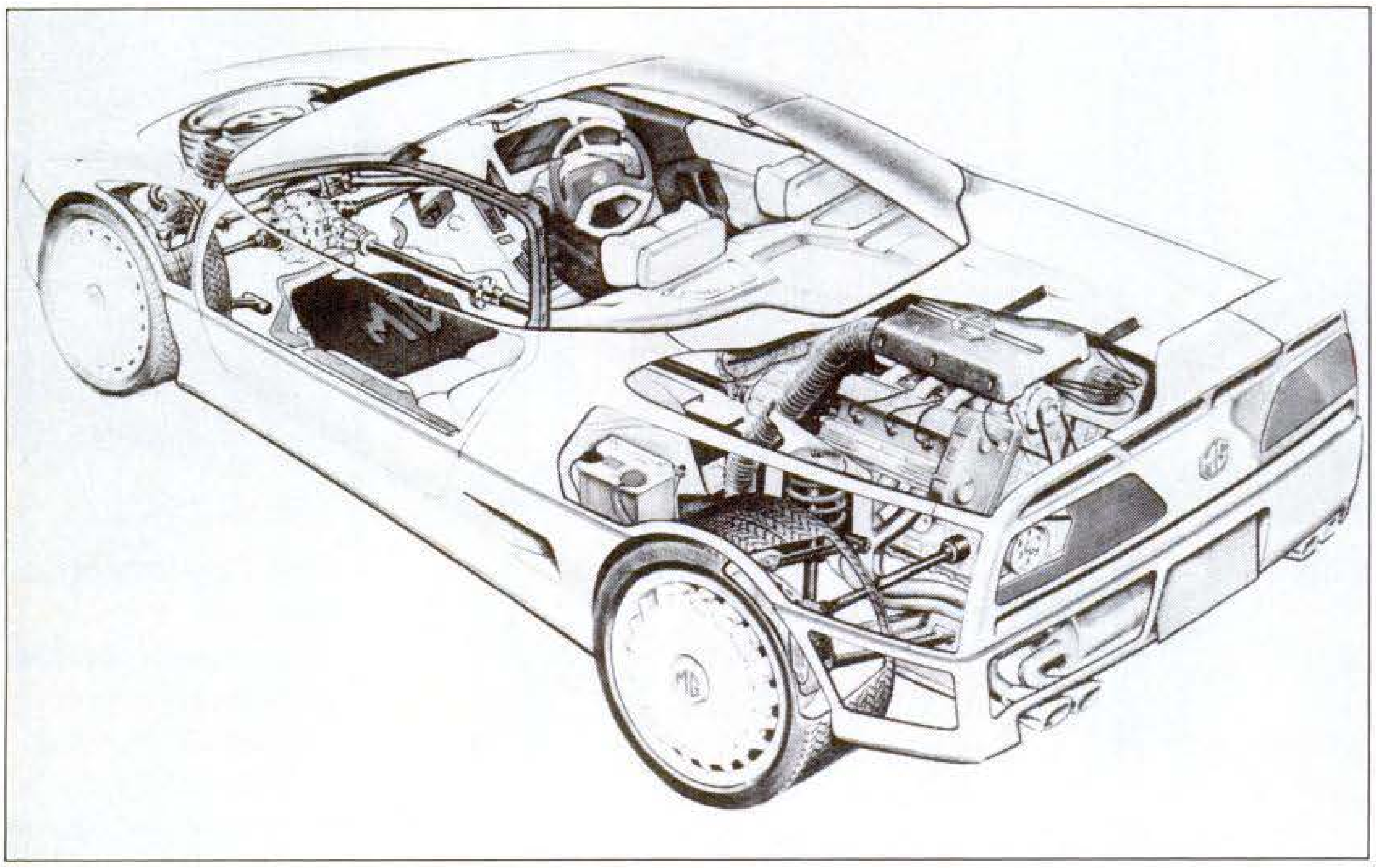
What's New

products/technology

Escape mask

Smoke Escape blocks carbon monoxide and other lethal gases for at least 20 min., claims the maker. The mask is easily secured and has a fog-proof panel for clear vision. Distributed by Latom Enterprises (287 Kimball St., Woodbridge, N.J. 07095), it's $65.



4WD sports car

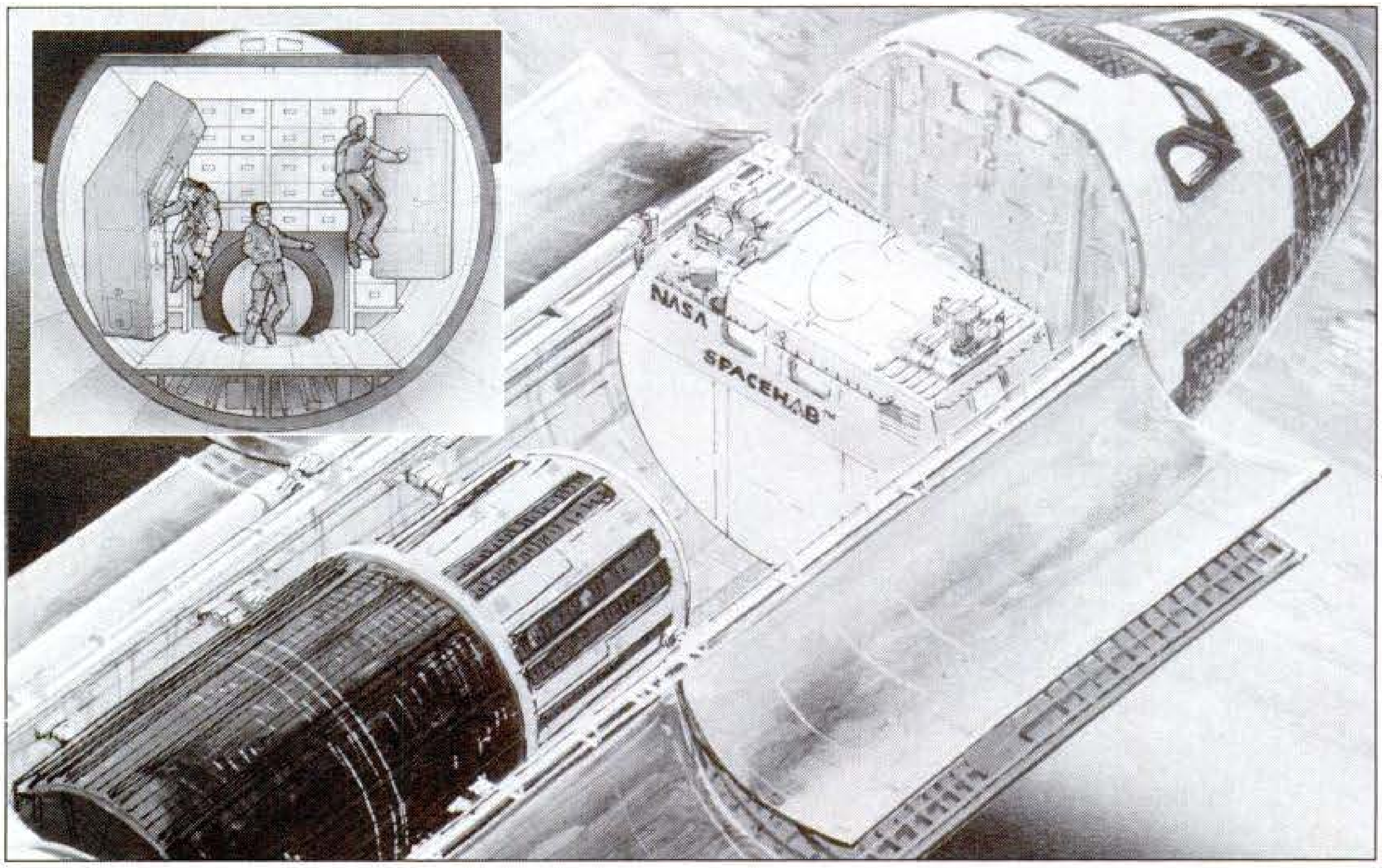
Austin Rover's MG EX-E 4WD concept sports car packs a 410-hp 24-valve V6. Projected top speed is 170 mph. The suspension varies ride height with speed and driving conditions. A coded card unlocks and starts the car, and adjusts the driver's seat and outside mirror.

Pocket microscope

Flip a switch on its self-illuminated pocket microscopes for close-up views at work or in your shop, says Solder Absorbing Technology (144 Oakland St., Springfield, Mass. 01108). The 4.5-oz. scopes are cigarette-pack size. A 30× magnification model is $19.50.

Turbo five-door

The Mazda 626 GT has a tuned intake manifold, a turbocharger, and fuel injection to help deliver 120 hp and impressive performance. To smooth rides, a computer signals an electronic suspension, controlling chassis dive, squat, and roll.



Shuttle modules

Plug-in modules for space-shuttle bays can boost living and work space by 1,000 cu. ft., says Spacehab (Washington, D.C.). The cylinders, to be ready late next year, will be 10 ft. long and 13 ft. in diameter. An air lock and tunnel adapter connect them to the crew compartment.

Adaptable wings

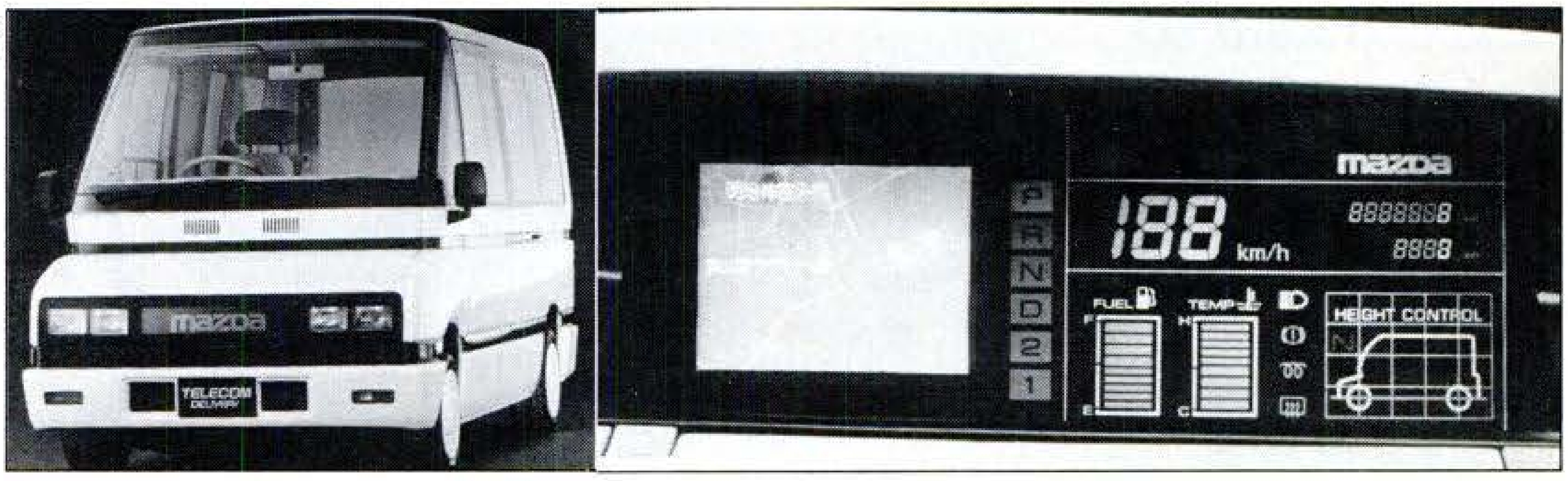
Modified wings on the AFTI/F-111 automatically change curvature for subsonic, transonic, and supersonic flight. Wings remain smooth, without the drag-producing gaps of flaps and ailerons. The F-111 recently had its first test flight at Edwards AFB, Calif.

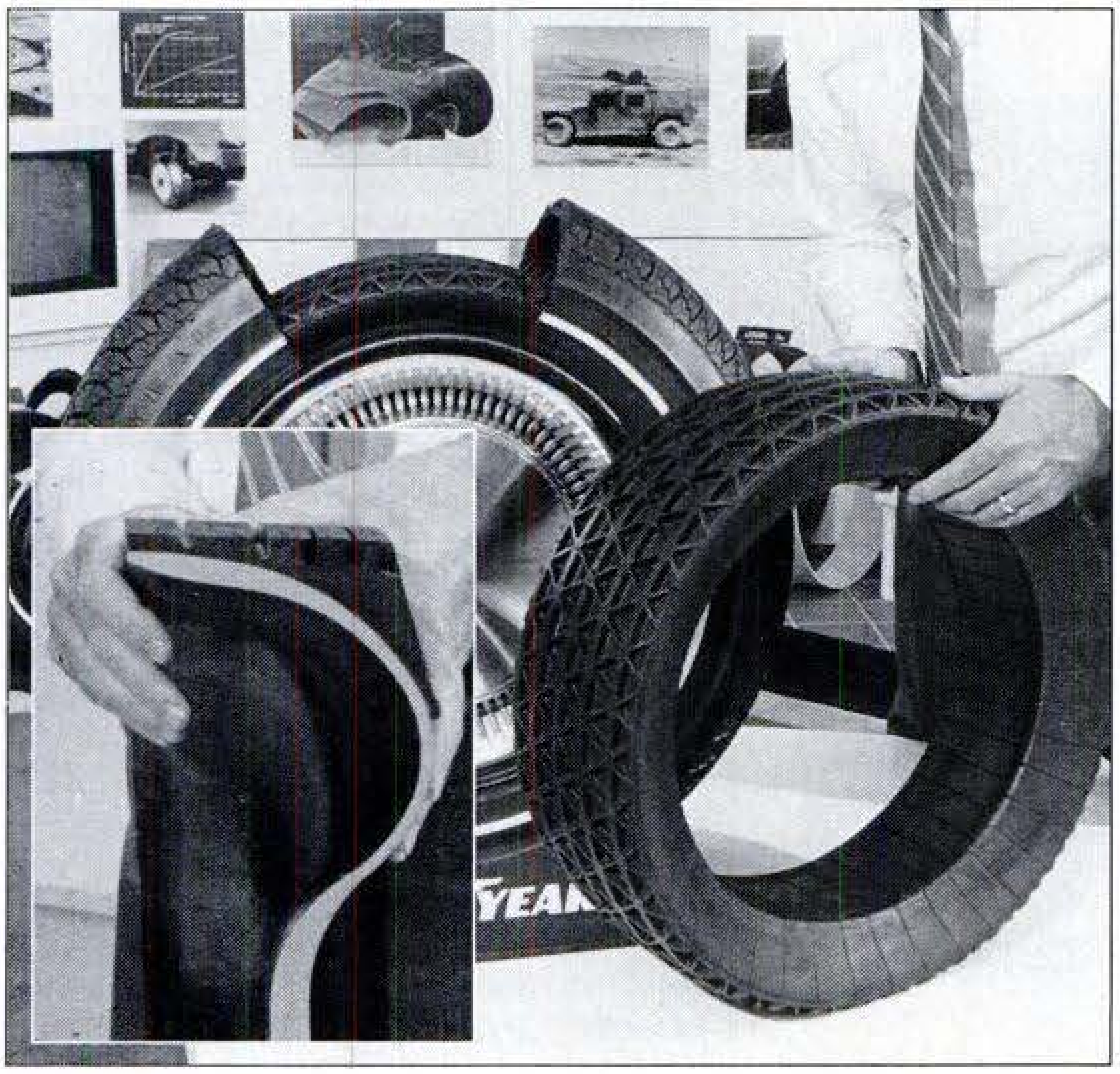
Mock-up copter

A full-scale LHX helicopter —the Army's mid-1990s multi-role aircraft—painted on an Apache chopper's fuselage adds realism to flight tests. Two McDonnell Douglas Helicopter (Mesa, Ariz.) pilots test avionics that help simulate maneuvers of future single-pilot LHXs.

Van navigator

Mazda displayed its Telecom Delivery van at a recent auto show. The prototype 1¼-ton vehicle has front-wheel drive. A navigation system with video display (far right) shows the driver on a map where the box-style van is located. Vehicle height adjusts for easy loading.





Future tires

Air loss from the outer section of Goodyear's run-flat tire causes a smaller tire to expand and fill the void. A different all-in-one spare tire-wheel (inset) is made of rubber bonded to fiberglass and epoxy. Goodyear unveiled both at its Akron, Ohio, technical center.

Bumper brakes

A touch-sensitive rear bumper triggers a truck's air brakes as it backs into a car—or even someone's leg. Stopping distance is less than 3 in. Brakes stay on until the driver shifts from reverse. Avon Backstop Div. (Melksham, Wilts SN12 8AA, England) makes the bumper.

What's New
in Photography

BY ARTHUR FISHER

Canon T90
CANON LENS MADE IN JAPAN

ZUIKO AUTO-MACRO

Fast macro

The Olympus Zuiko 50-mm Auto-Macro lens is the first of its kind with a maximum aperture of f/2.0, a considerable aid to the critical problem of sharp focusing in close-up photography. Maximum magnification is 1:2, at a distance of 4.5 in. List price: $400.

FUJI
AX MULTI PROGRAM
DX
X-FUJINON
FUJI PHOTO FILM JAPAN

Auto-exposure SLR

A choice of three programmed exposure modes is available with the Fuji AX-MultiProgram 35-mm camera: P (normal), HP (high-speed priority), and DP (depth-of-field priority). An LED display in the viewfinder shows which is operating. It costs $299.

Three-motor 35

Canon's latest addition to its noted T-series is this ultra-sophisticated 35-mm reflex, the T90. With three motors for different functions, it can shoot 4.5 frames per second. Other features include three switchable metering patterns and a $\frac{1}{4{,}000}$-sec. shutter speed. Price is not set.

Accurate spot meter

For critical exposure situations, a spot meter with a 1° acceptance angle can be an invaluable supplement to a camera's own meter. From Spiratone (135-06 Northern Blvd., Flushing, N.Y. 11354-4063), the SP-I analog model shown is $100; a digital model costs $140.

Viewing aid

This clever adapter for a 6× magnifier accepts both 35-mm slides and film strips. And the clear plastic base is cut away to make print spotting easier. The two-achromatic-lens magnifier is $43; the adapter, $6. Edmund Scientific, Edscorp Bldg., Barrington, N.J. 08007.

RICOH
KR-30SP
PROGRAM
RIKENON P 1:1.7 50mm
LENS MADE IN JAPAN

Fancy-feature SLR

Unusual features of the Ricoh KR-30SP 35-mm SLR include a high-precision ceramic-timed shutter with speeds from 16 to $\frac{1}{2{,}000}$ sec., and an LCD analog control center that shows exposure mode, match needles, speed and aperture, and more. Price with f/1.7 lens: $370.

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What's New *in Home Improvement*

BY SUSAN RENNER-SMITH

Stove stretcher

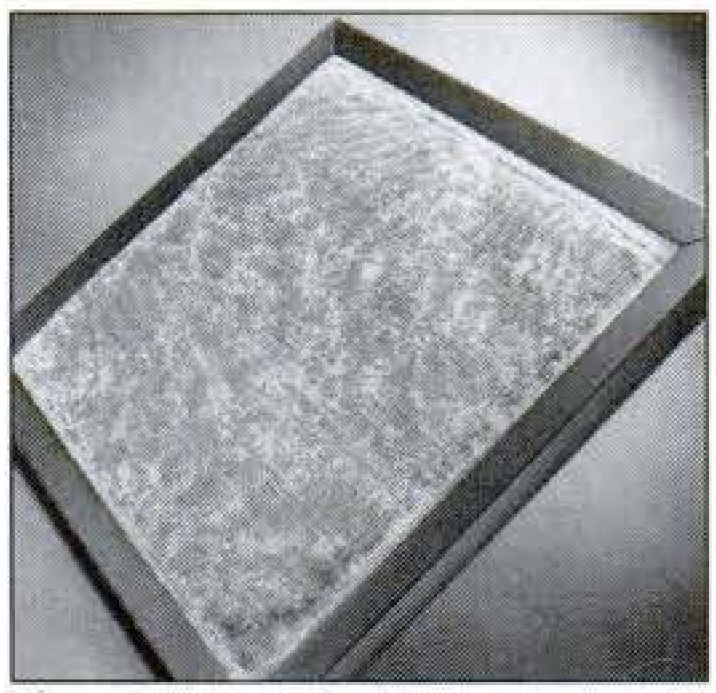
Do pots crowd your stove when you cook? Sears' induction cooker with its 1,300-W "High" setting serves as an extra burner. Like large induction cook tops, the $130 plug-in cooker uses electromagnetism to heat the pot, not the top. And its 50-W setting keeps foods warm.

See-through duct

The See-Vent transparent dryer duct lets you easily check for lint buildup. Why bother? Lint plugs can overload the motor. The clear polyester ducting, supported by high-tensile wire, is UL listed and costs $7. Maker: Nemco Inc. (Box 105, Grand Haven, Mich. 49417).

Planter light

Your plants can thrive in dark corners—if you clip on this miniature Gro Light, says Zelco (630 S. Columbus Ave., Mt. Vernon, N.Y. 10550). The 6-in.-long fluorescent bulb substitutes for the sun, the maker claims. And the lamp's arm stretches up to 40 in. Price: $34.



Radon fighter

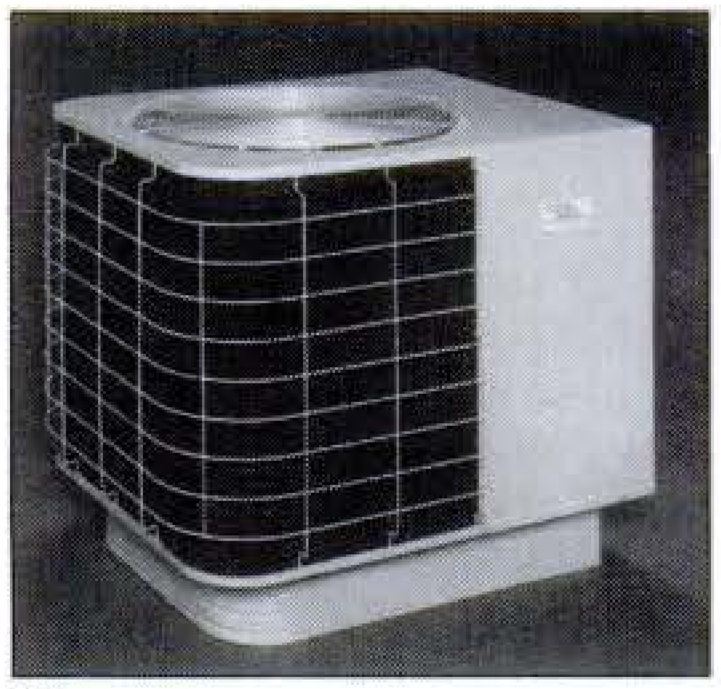
Replace your furnace filter with a MagnaStat, and you get a whole-house air cleaner for $200, says Econergy Systems (Box 410, Slidell, La. 70459). Two screens trap particles while an advanced activated-charcoal filter removes gases—including radon—the maker claims.

Heater throttle

Unlike most thermostats, Power Pulse doesn't cycle its resistance heater on and off. Instead it constantly sends the heater the exact current needed to maintain the setting. The $50 unit cuts energy costs up to 21%, says Intertherm (10820 Sunset Office Dr., St. Louis, Mo. 63127).

Fancy flooring

You almost have to touch it to be sure it's not marble. Special luminescent pigments give Congoleum's Marblesque sheet vinyl flooring the rich look of polished marble. A random grain pattern enhances the realistic effect. The 12-ft.-wide flooring costs approximately $20 a sq. yd.



Energy saver

With a Seasonal Energy Efficiency Rating of 11.3 to 12.0, the Coleman T.H.E. II heat pumps are among the most efficient on the market, the maker says. Four models range in size from 1.5 to three tons and in price from $2,350 to $2,950.

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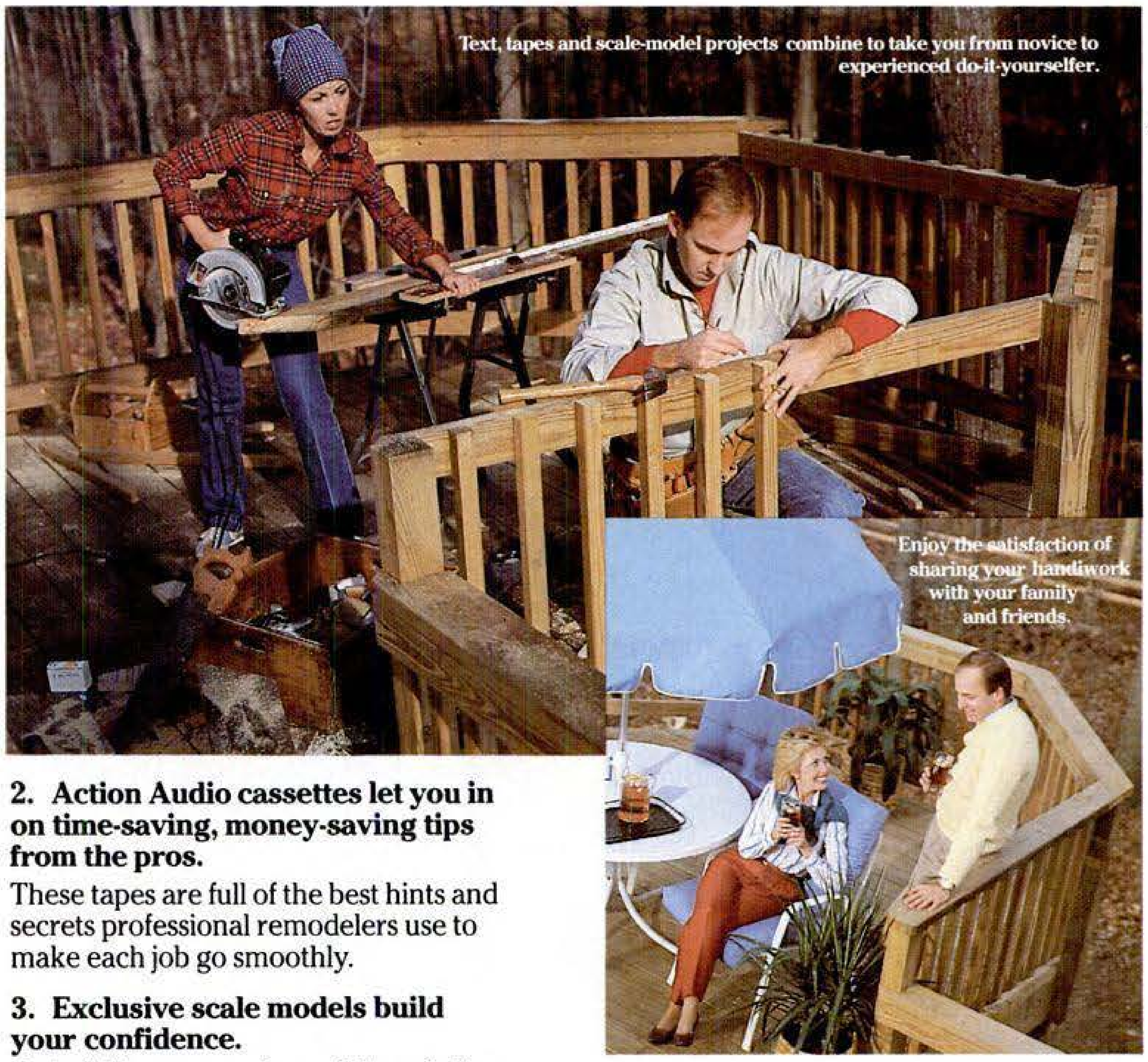

Text, tapes and scale-model projects combine to take you from novice to experienced do-it-yourselfer.

Enjoy the satisfaction of sharing your handiwork with your family and friends.

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These tapes are full of the best hints and secrets professional remodelers use to make each job go smoothly.

3. Exclusive scale models build your confidence.

By building your scale models and other hands-on projects, you'll gain priceless self-confidence. You'll know that you'll build your full-size project right because you've already built it to scale and learned to avoid costly mistakes.

You'll learn everything you need to know

The modules will teach you to do all of today's most-wanted home improvements: install kitchen cabinets • improve energy efficiency • enlarge an existing deck • improve or add a bathroom • add a sunroom • build an addition or move a wall to enlarge your living space • and more!

With your very first module, *Decks and Patios*, you'll build an actual deck addition to scale. You'll learn to set foundation posts, run stringers, build steps, estimate materials, and get the best buys on lumber. There's even a section on custom-designing deck plans to make your house look its very best.

Now everyone can do it themselves and save!

McGraw-Hill will help you join the thousands of smart home owners who've discovered the personal and financial rewards of "moving up without moving out."

Start With *Decks and Patios*—15-day trial examination

Just send the postcard today! When your first module arrives, examine it and see for yourself how clearly the text covers every aspect of deck construction. Listen to the pro tips on the Action Audio cassette, and even begin your scale-model deck project.

You'll also receive a valuable FREE booklet, "Smart Money in Home Improvements"—a planning guide to getting the maximum return on your home improvement investments. It's our gift to you, to keep even if you decide to return your first module within the 15-day examination period. If the Series is not all we say it is, simply return the first module... there's no obligation and you'll receive no further modules.

Act today and start learning to save big on every home improvement!

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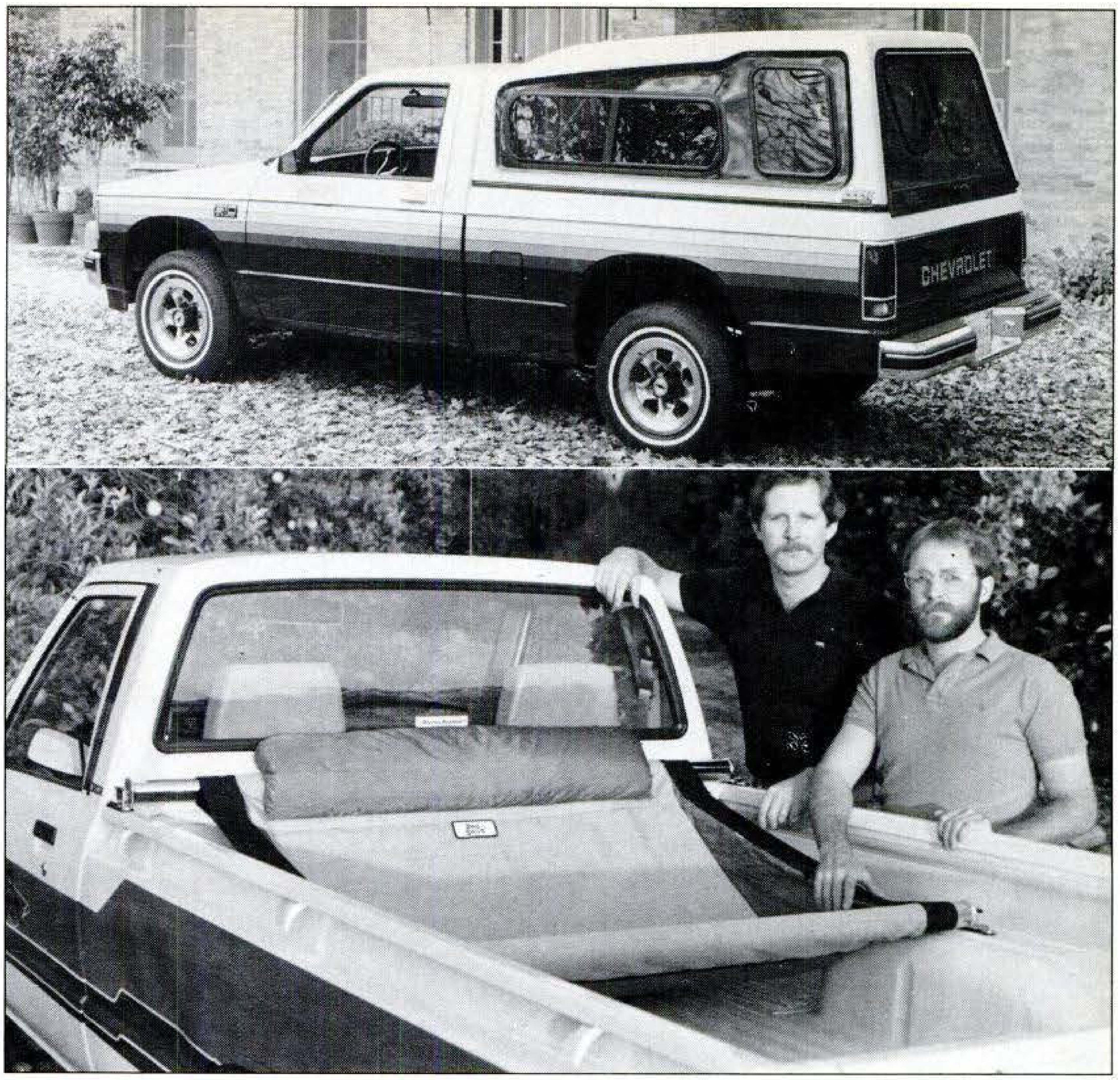
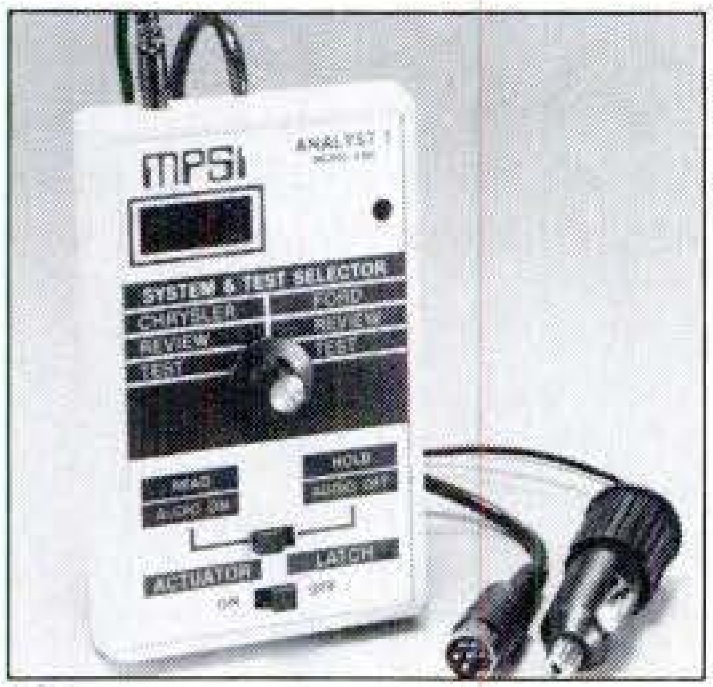
What's New
for Your Car

BY JACK KEEBLER



Two for trucks

The Crown 190's wedge profile (top) ensures good fuel economy and head room, says Leer (58288 Ventura Dr., Elkhart, Ind. 46517). Leer's Privacy Pack option, a heavy 31% tint for windows and black anodized window frames, screens out sun and conceals contents. Price: $775. Not enough room in your pickup for everybody? The 2nd Seat's twin telescoping steel spars attach to tiedowns on the truck's bed rails and wheel wells, creating a rigid frame for the seating system. Fryford Corp. (30052 Running Deer Lane, Laguna Niguel, Calif. 92677) says it stows behind the front seat. Price: $229.



Black-box reader

The Analyst 1 plugs into a vehicle's diagnostic connector to provide instant access to fault codes and test data. Micro Processor Systems Inc. (7641 19 Mile Rd., Sterling Heights, Mich. 48078) says it will read all 1981–'86 Ford and 1983–'86 Chrysler on-board computers. $120.

PHILIPS
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KEEP THIS CARD IN A SAFE PLACE
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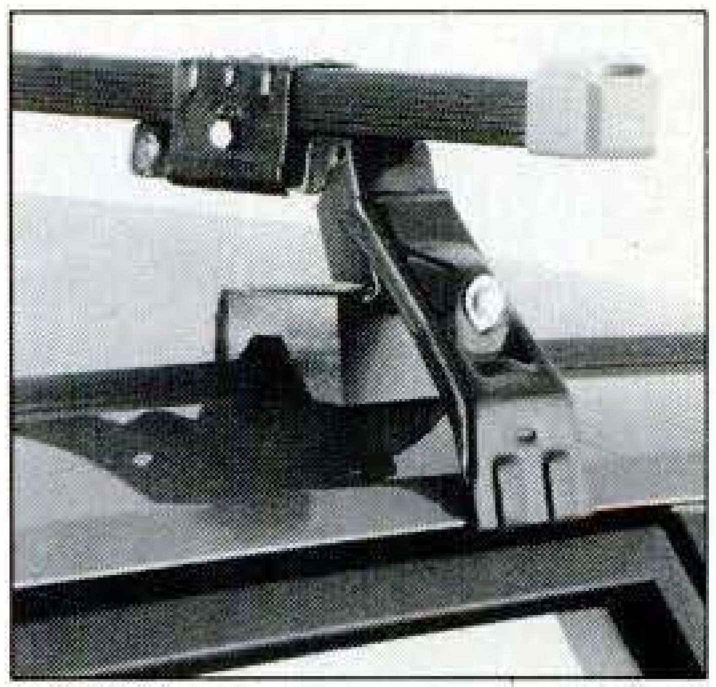
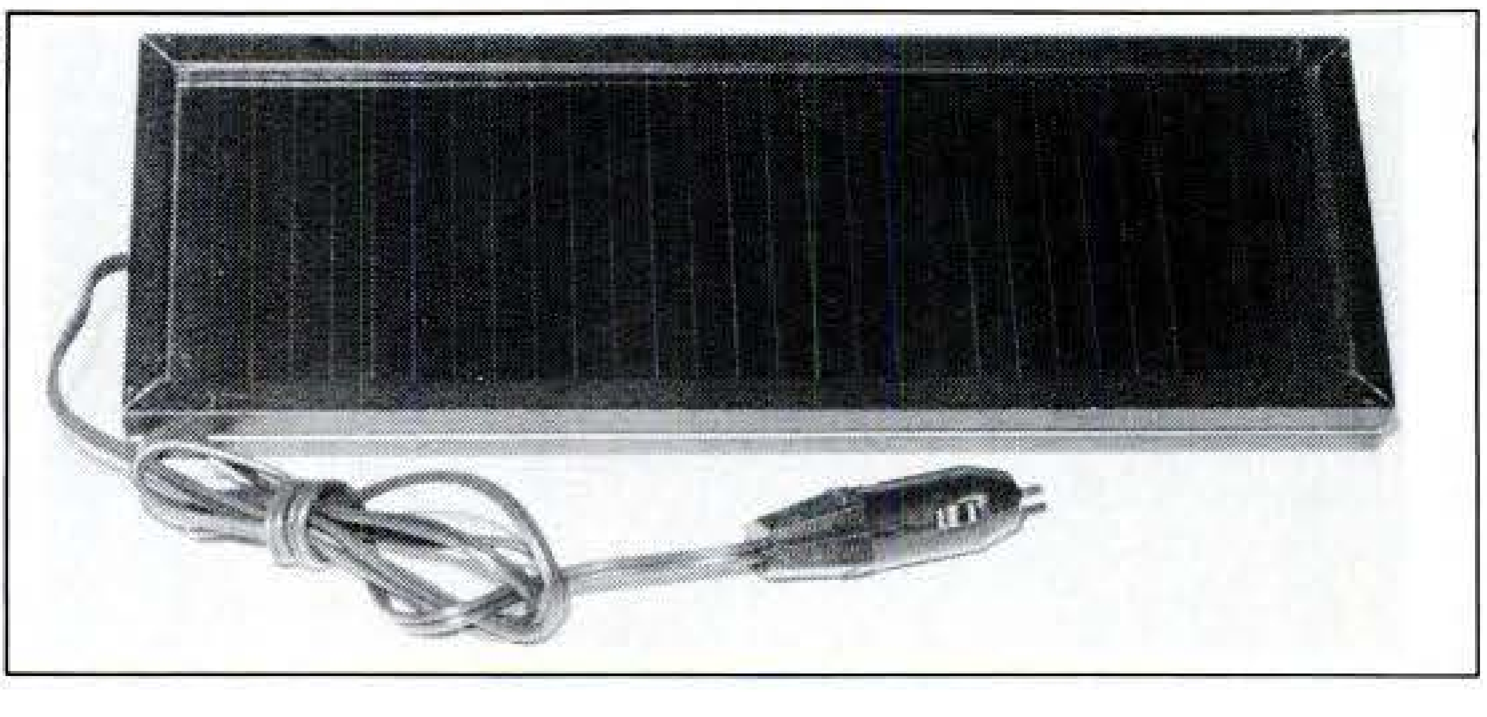
Coded radio

The Philips DC751 radio isn't worth stealing: It won't work if it's removed from your car. Punch in your three-digit security code: If the power to the radio is disconnected, the operating code is lost. Maker: Philips, Box 523, 5600 AM Eindhoven, Netherlands.



No-gutters rack

Do you have an aerodynamic vehicle with no gutters on which to install a roof rack? Mill Accessory Group (Eaton Bray, Beds LU6 2JH, England) says its load-bar kit with no-scratch feet clamps to the roof as securely as a conventionally mounted rack.

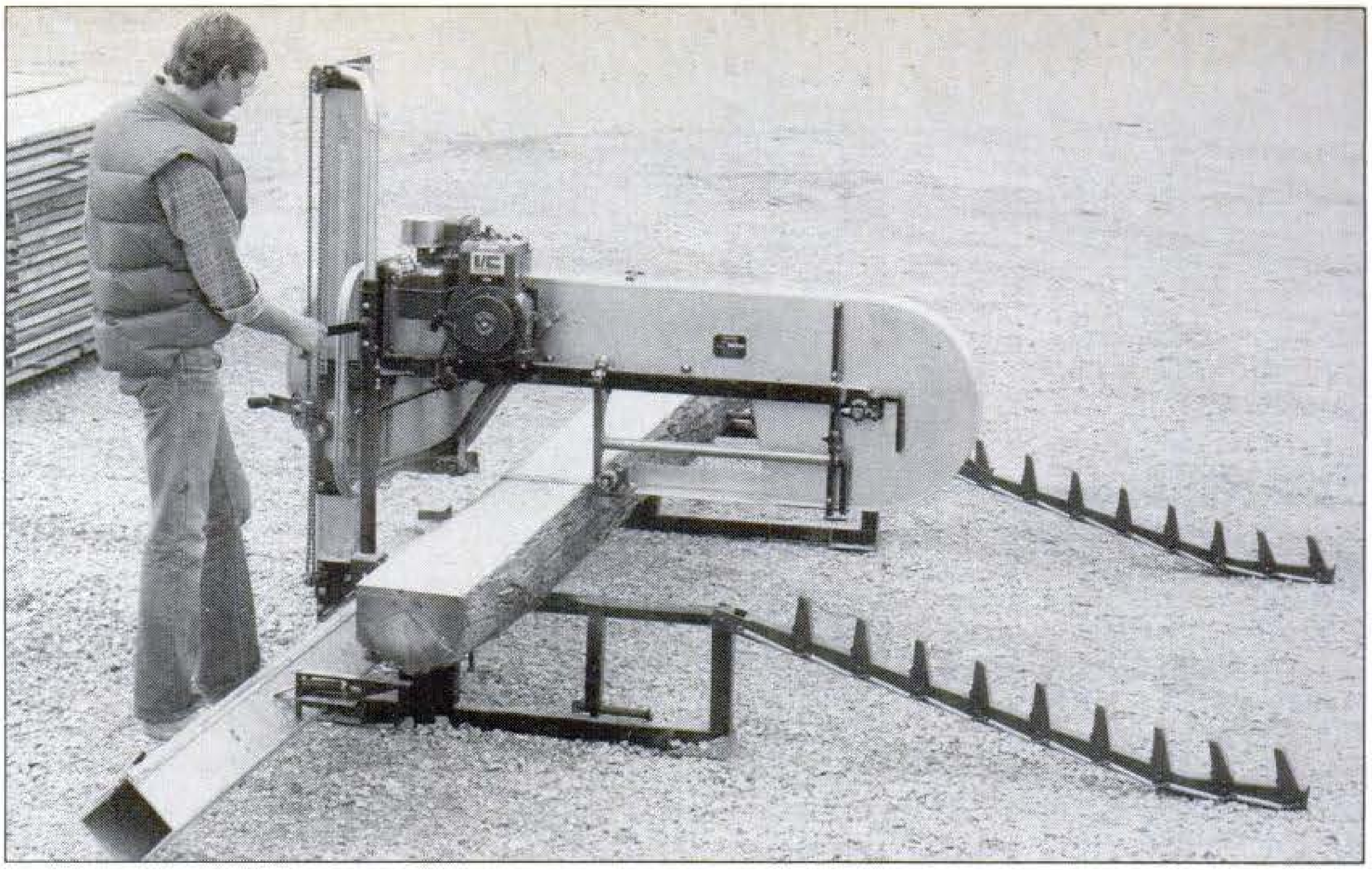


Solar charger

If you leave your car sitting for long periods, you may return to find its battery dead or seriously weakened. That won't happen if you plug the $39 Maintainer solar panel into your cigarette lighter, claims Solar Electric Engineering (405 E. D St., Petaluma, Calif. 94952).

What's New *in Tools*

BY V. ELAINE GILMORE

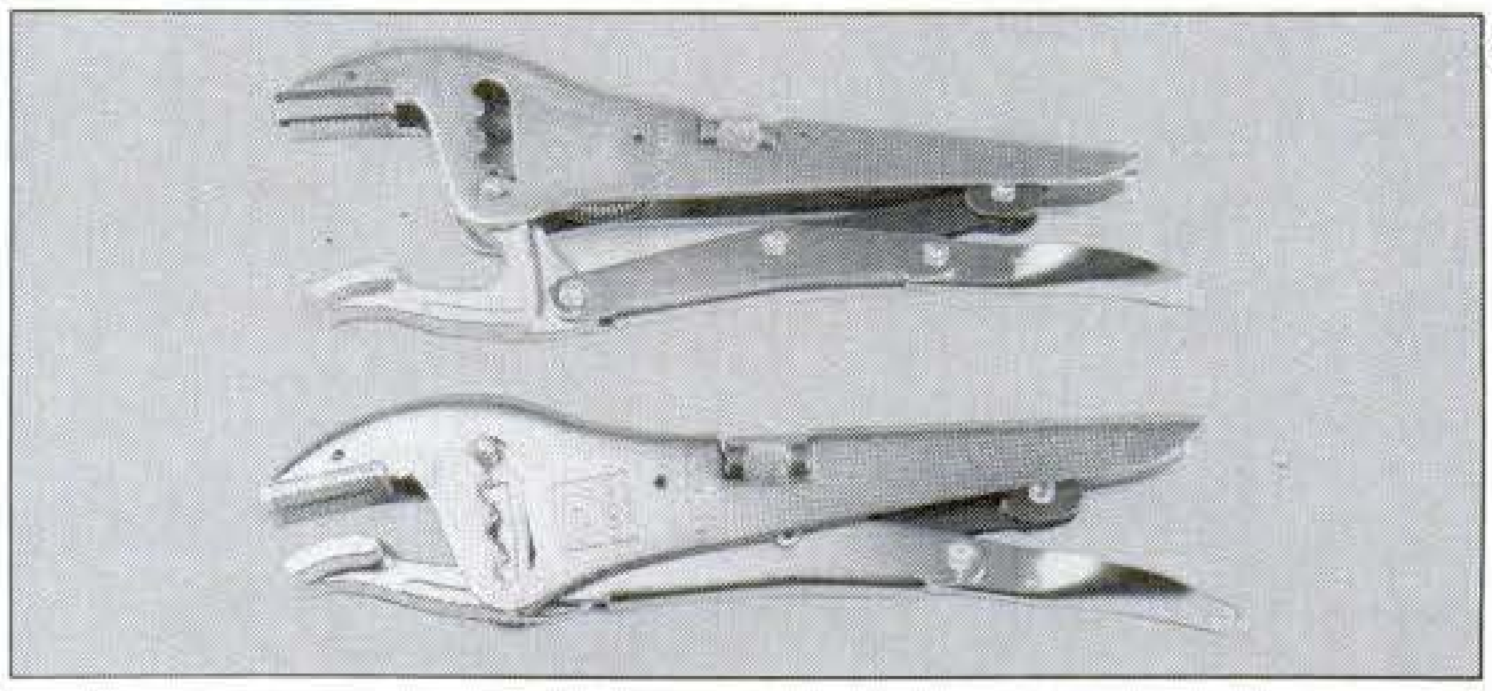


Thin-kerf mill

The $3,995 Wood-Mizer LT20's band-saw blade leaves only a 1/16-in. kerf, so you get more lumber from a log. The sawmill can cut boards up to 24 in. wide and 16⅓ ft. long, yet it fits in a mini pickup. Laskowski Enterprises, 8180 W. 10th St., Indianapolis, Ind. 46224.

Solder to go

With a flick of the built-in flint, you can fire up this butane-powered soldering iron, and work for 1 hr. on a fill. The tip, a flameless catalytic converter, heats in 30 sec., says Boardworks (Box 1678, Covina, Calif. 91722), which imports the Portasol ($25) from Ireland.

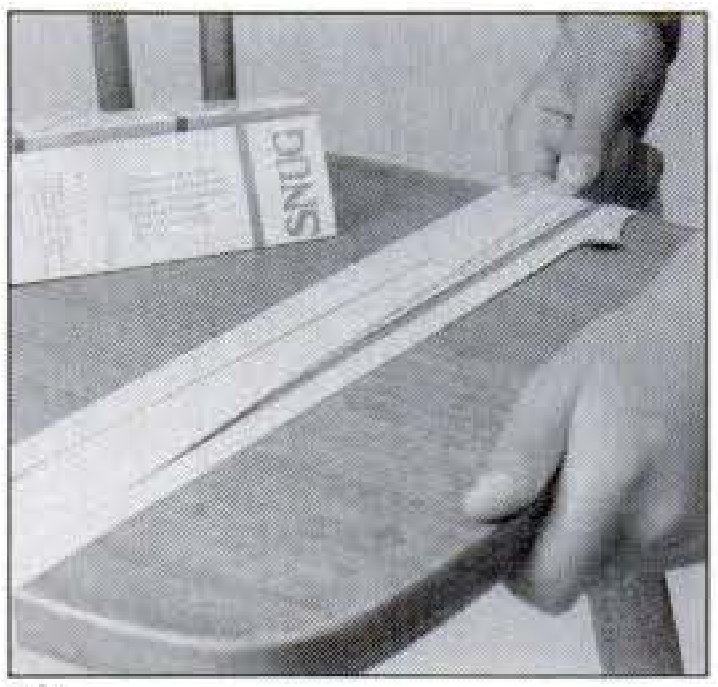


British big mouths

One hand is all it takes to open, clamp, and release these big-bite Lockgrip 500 pliers from Facom Tools Ltd. (Bridge Rd., Chertsey, Surrey KT16 8LJ, England). They apply a one-ton clamping force, it's claimed, and come in seven sizes, with jaw openings from 2 to 5.7 in.

Bargain bench

You can own a European beechwood workbench for less money than you may think. Woodcraft Supply (Box 4000, Woburn, Mass. 01888) sells the 46¾-in.-long Handyman for $235 and the 76¼-in. Craftsman for $345. Both have shoulder and tail vises, tool trough, drawer.

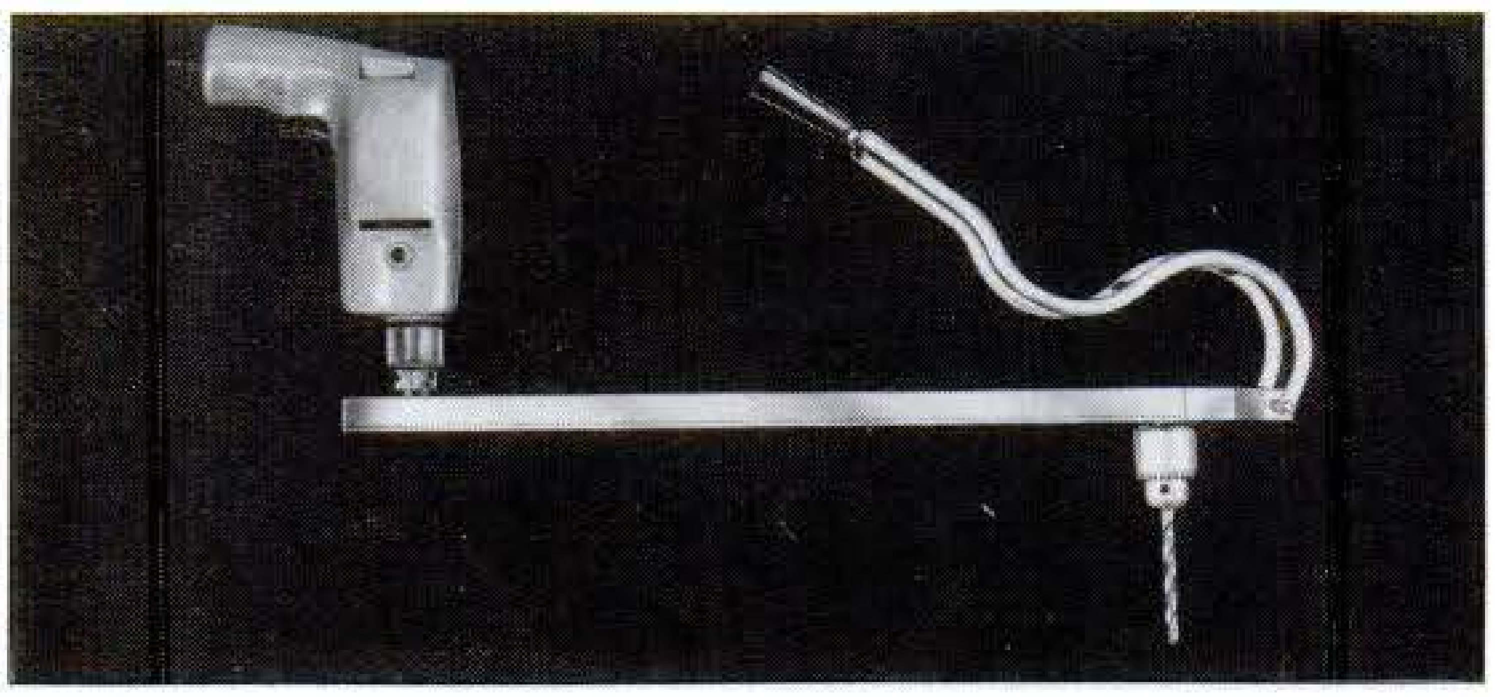


Wrap clamp

How do you clamp the shards of a china cup while the glue dries? Or a sole you're cementing to a shoe? Carrollton Corp. (70 Carrollton Ave., Elmira, N.Y. 14905) suggests Snug, a stretch-plastic strip that sticks to itself. Snug ($4 for 20 ft.) also can sub for tie-downs.

Reacher

Drill-X-Tend adds 12, 18, or 24 in. of reach to any drill, notes MacGregor Mfg. (223 Springdale Ave., York, Pa. 17403). You put your drill in the tool, and a chain drive transfers power from it to the ⅜-in. chuck. The three sizes are $79.50, $94, and $100.50; the handle: $20.



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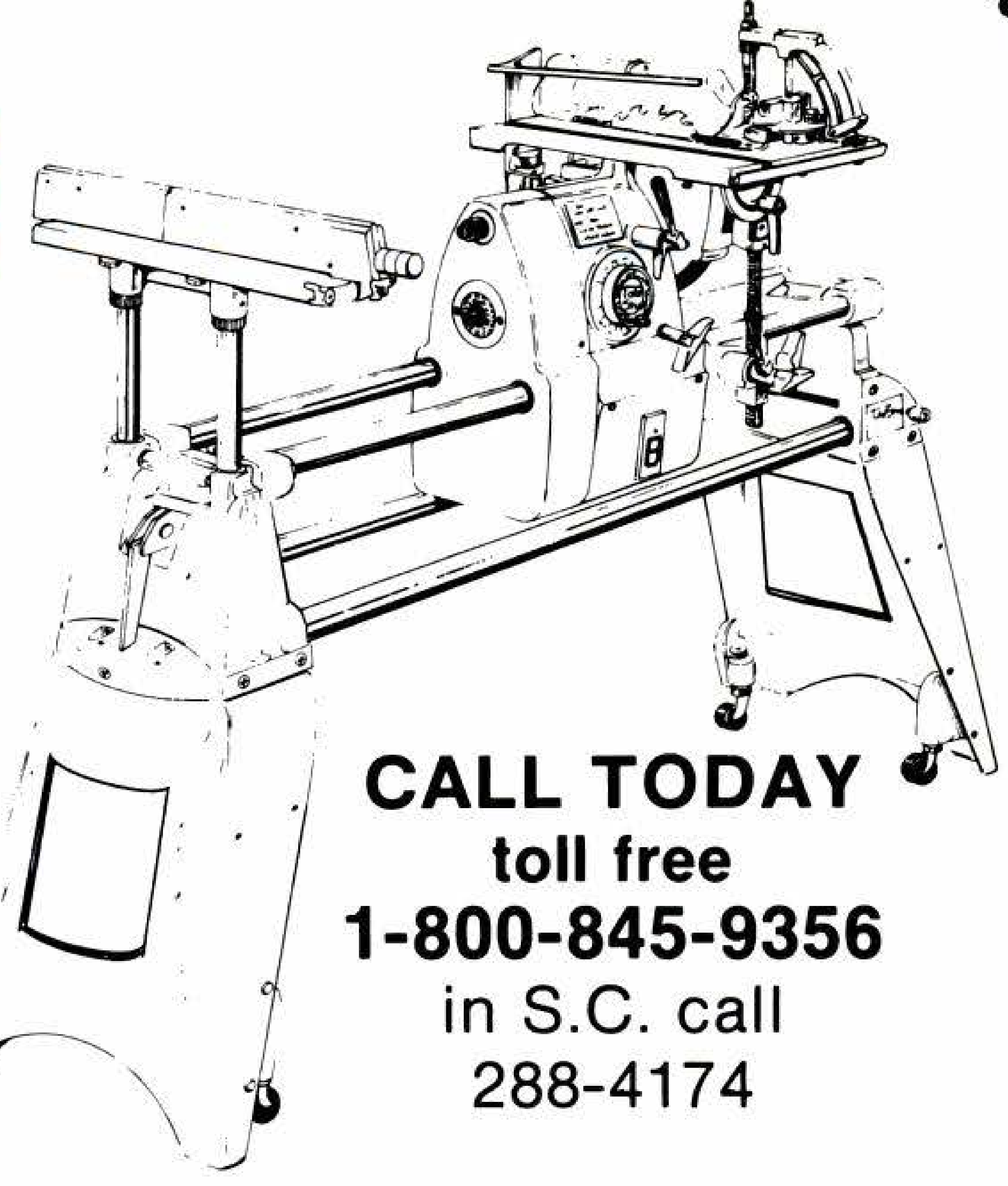

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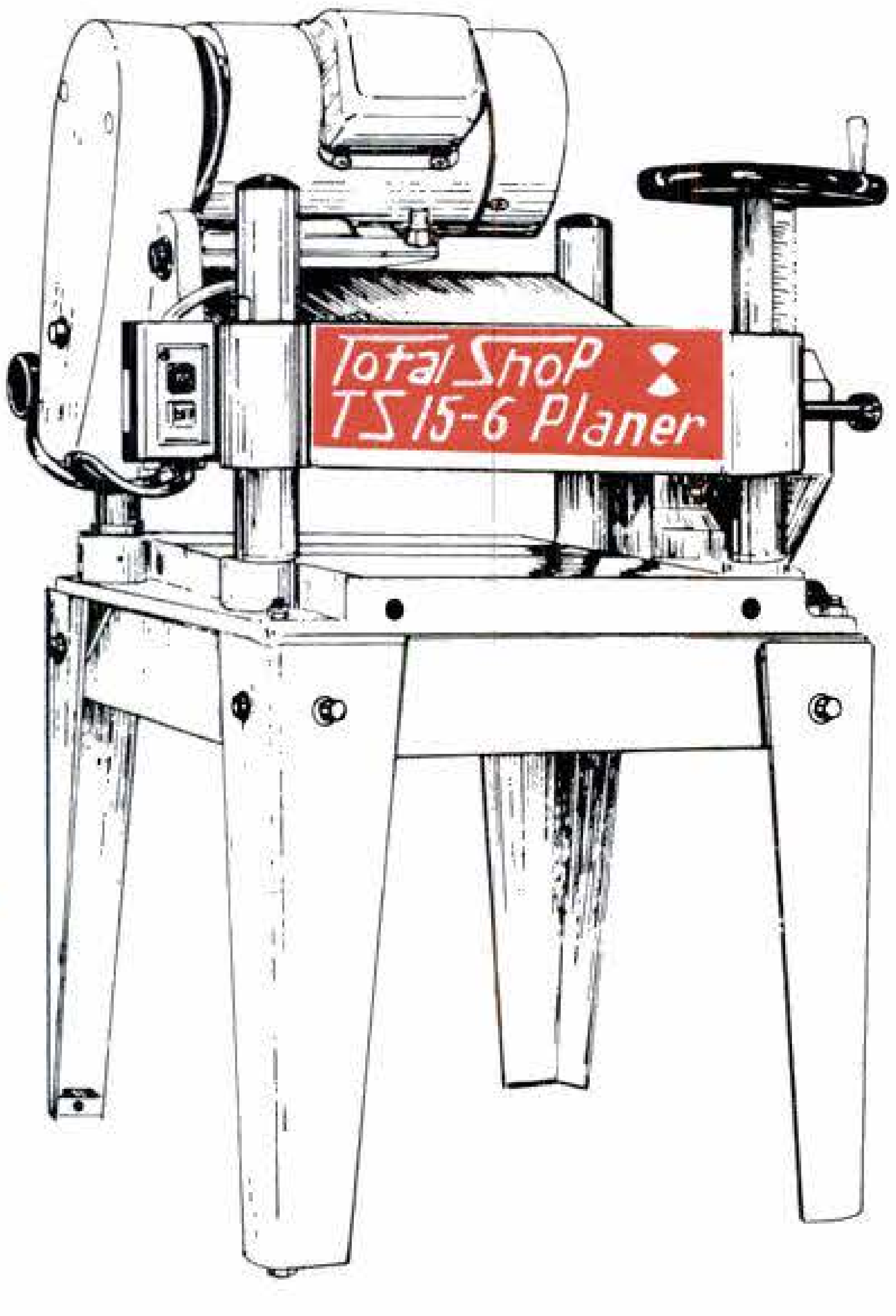

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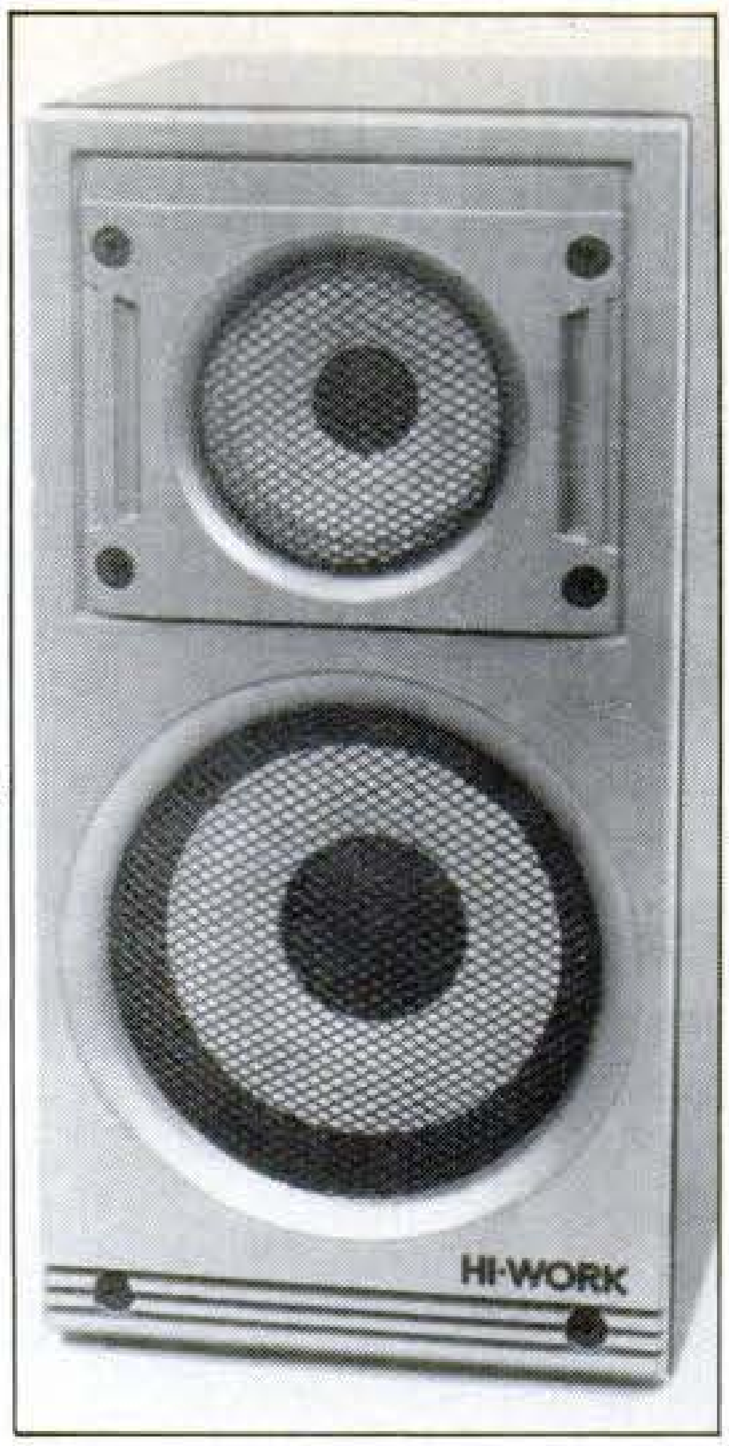
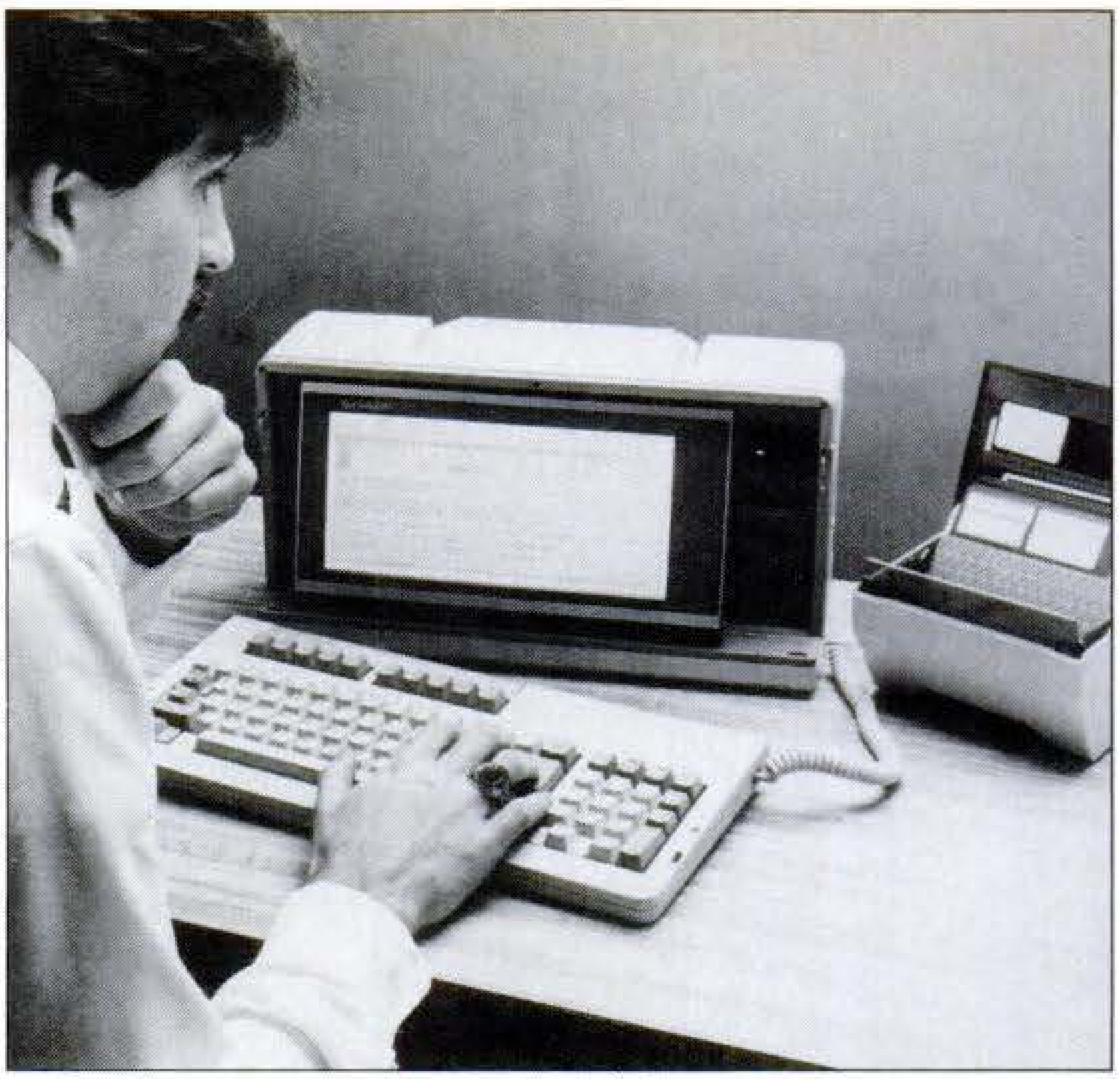
What's New
in Electronics

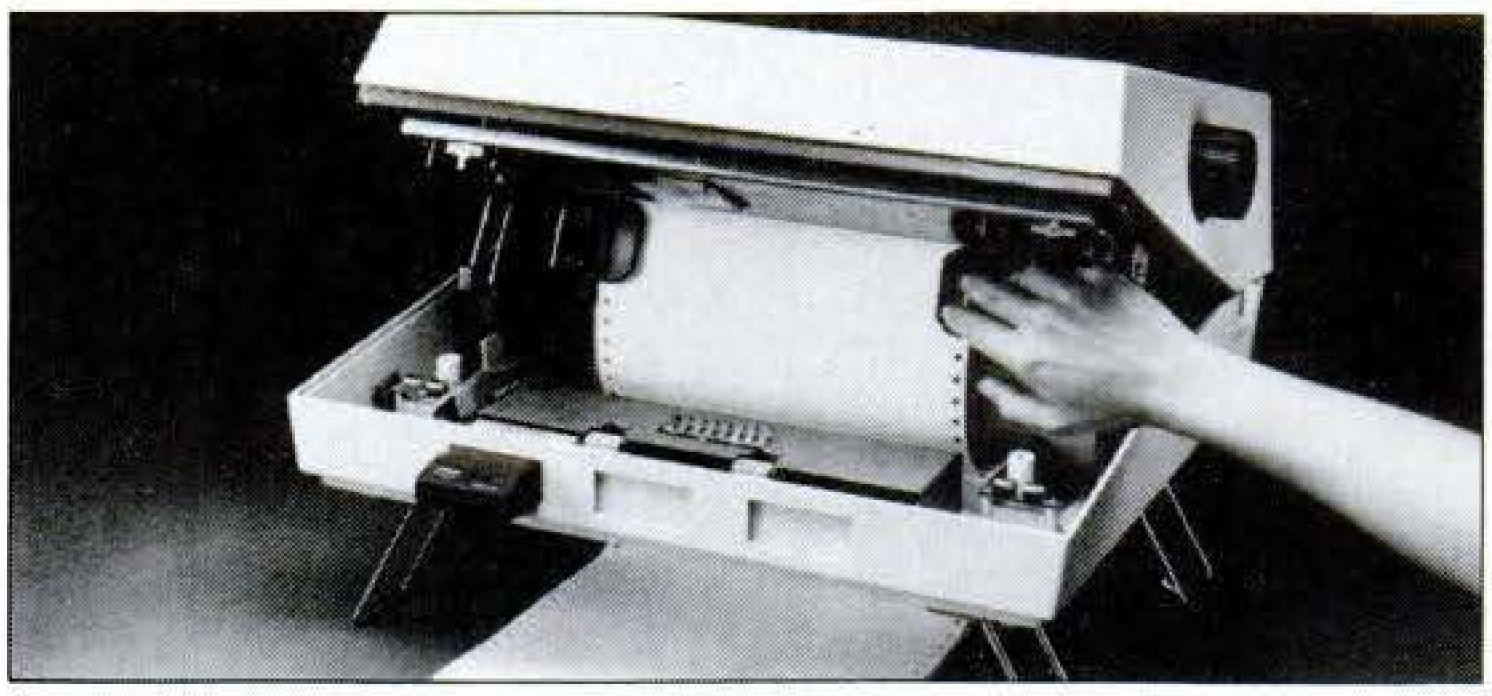
BY WILLIAM J. HAWKINS





Wireless speaker

The hi-fi is in one room, but you hear music in any other that contains the Hi-Work shoe-box-sized speaker. Audio is sent from a transmitter at the hi-fi to the speaker via existing AC lines. From Breakthrough Marketing (4 James Way, Rye Brook, N.Y. 10573), it's $100.



Easy loader

The Genicom (Waynesboro, Va. 22980) dot-matrix letter-quality printer opens like a clamshell for easy paper loading. The printer accepts plug-in font cartridges for special printing as well as modules for making it mimic other printers (IBM, Epson, and Diablo). It's $699.

Easy-to-see LCD

An electroluminescent panel backlights the LCD screen on the Sharp PC-7000: High-resolution (640 by 200 dots) 80-column-by-25-line text displays are easy to see under all lighting conditions. The $2,000 MS-DOS computer has two 5.25-in. disk drives and 320K of memory.

Stereo-TV maker

Attach this Radio Shack stereo receiver to your audio-video system. Result: stereo TV. The variable tuner lets you select any VHF or UHF station. LEDs automatically show when a broadcast is in stereo or when a Special Audio Program is received. The TV-100 costs $140.

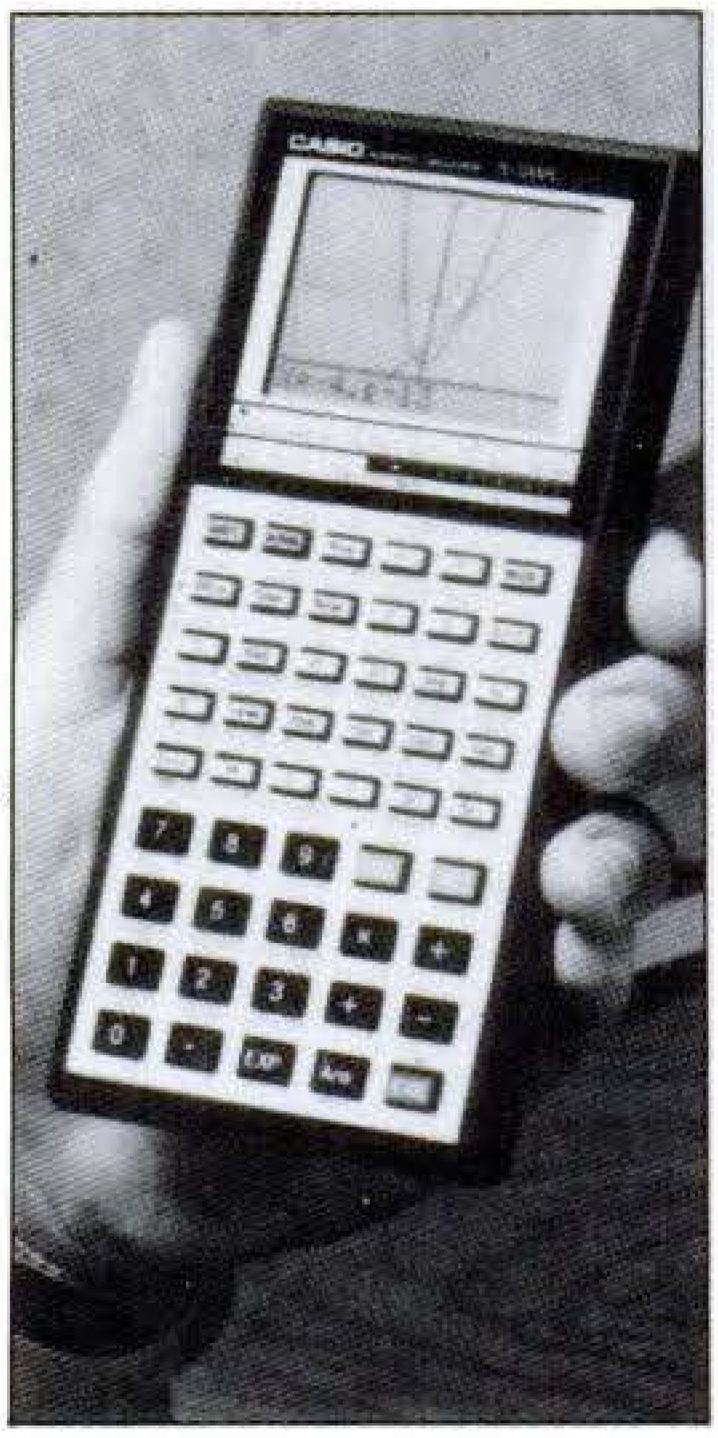
REALISTIC TV-100 STEREO TV RECEIVER

Word processor

Videowriter replaces home typewriters, according to the maker, Magnavox. The $800 word processor lets you create and edit text on its 80-column-by-18-line display, save up to 70 pages on a 3.5-in. disk, and print in up to five typefaces on its built-in printer.

Graphic calc

Enter an equation on Casio's pocket scientific calculator, and it gives you the answer—graphically. The clever calc uses a 96-by-64-dot LCD display to show graphs, fluctuating points, or several equations simultaneously. The computer-like FX-7000G is $100.



ESCORT
1 3 5 7 9
RADAR WARNING RECEIVER
VOLUME
HIGHWAY
CITY
ALERT

It's Unanimous

(Even the competition says ESCORT's the one to beat)

It's easy to see who sets the pace in radar warning. Just read all the detector ads. Most of them claim to be as good as ESCORT. A few say they're better.

At least they agree on one thing. ESCORT is the one they have to measure up to.

A modern classic

ESCORT was a radical piece of electronic engineering in 1978 when it was introduced, the first practical use of superheterodyne technology to warn of police radar. *Car and Driver* magazine said, **"...the radar detector concept has finally lived up to its promise."**

Since then, our engineers have never stopped refining that technology. ESCORT may look the same on the outside, but it never stops getting better on the inside.

Standard of comparison

Now, when experts refer to the high-water mark in radar protection, they automatically turn to ESCORT. In March of this year, *Car and Driver* published its latest detector test, this one comparing remote-mounted models. ESCORT is designed for dashtop or visor mounting. But the magazine included ESCORT in the test anyway, as the reference against which the performance of the others would be measured. ESCORT scored 412 points in the final rating, compared to 274 for the highest-finishing remote. You might say the comparison showed that there is no comparison.

A gilt-edged reputation

Seven years is a long time in the radar warning business, but there is no shortcut to a good reputation. *Car and Driver* said, **"The ESCORT radar detector is clearly the leader in the field in value, customer service, and performance..."**

unit has the "new" ST/O/P™ circuitry.
n Escort...
Escort™? N
ner than Escor
Escort has
ESCORT
Escort and ST/O/P are registered trade
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ESCORT
Mail your Escort owner's manual and
FOR ESCORT OWNERS:
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an Escort's ST

These excerpts were taken entirely from advertisements for other radar detectors.

So it's easy to understand why other detectors would try to stand in our limelight. ESCORT has seven years worth of credibility, the one quality that money can't buy in this business.

Check our references

Credibility doesn't come from extravagant claims. It comes from satisfying customers. You probably know someone who owns an ESCORT (nearly a million have been sold). So ask about us.

ESCORT pioneered superheterodyne receiving circuitry. Ask if our radar warnings always come in time.

ESCORT's reporting system combines an alert lamp, a variable-rate beeper that distinguishes between X and K band, and an analog meter, all to give an instant indication of radar strength. Ask if our warning takes the panic out of radar.

ESCORT is sold in one place only, the factory that makes it. This lets you deal directly with experts. Any of our staff of over 60 sales people will be glad to answer any questions you may have, about ESCORT or about radar in general.

We've been solving people's radar problems since 1978. How can we help you?

Try ESCORT at no risk

Take the first 30 days with ESCORT as a test. If you're not completely satisfied return it for a full refund. You can't lose.

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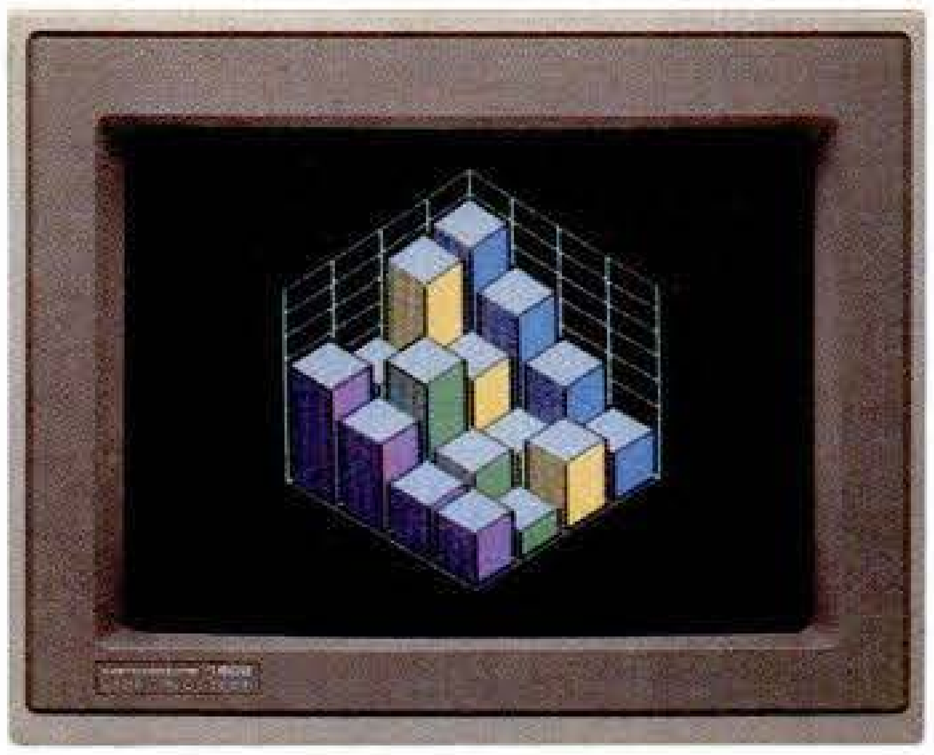
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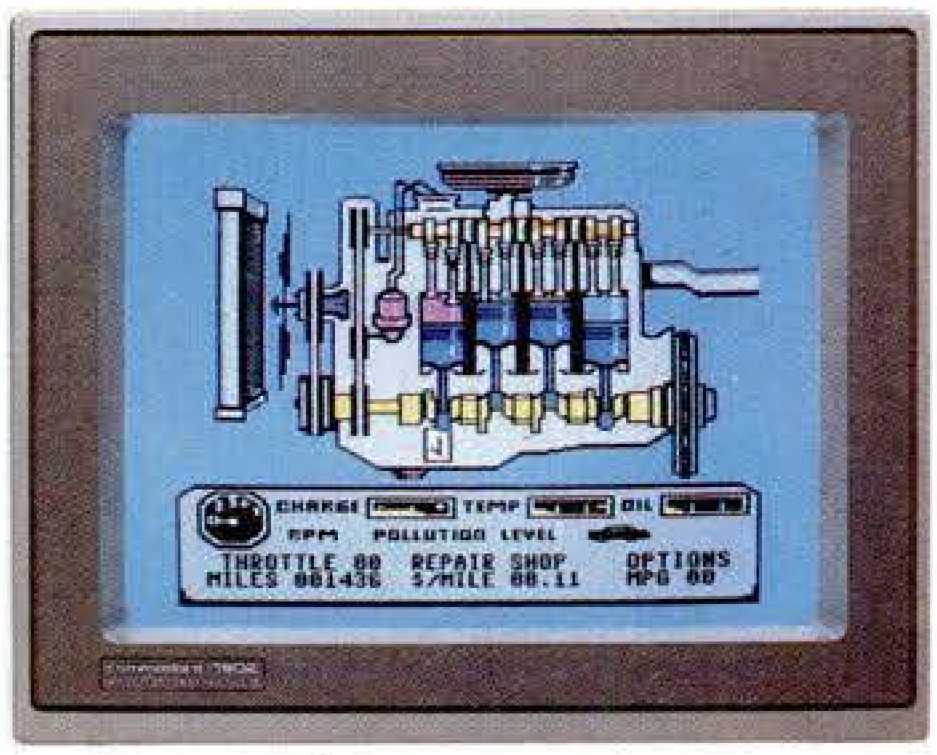
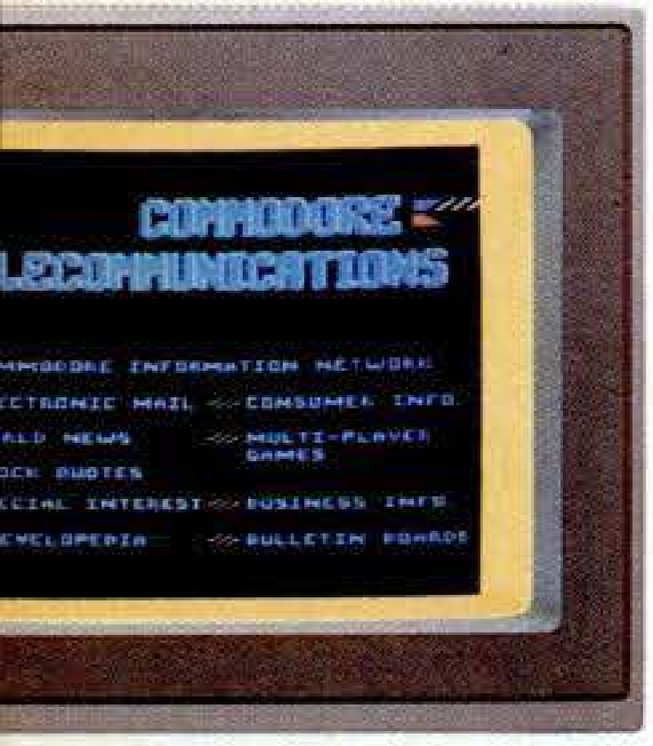
write a novel


fix an engine

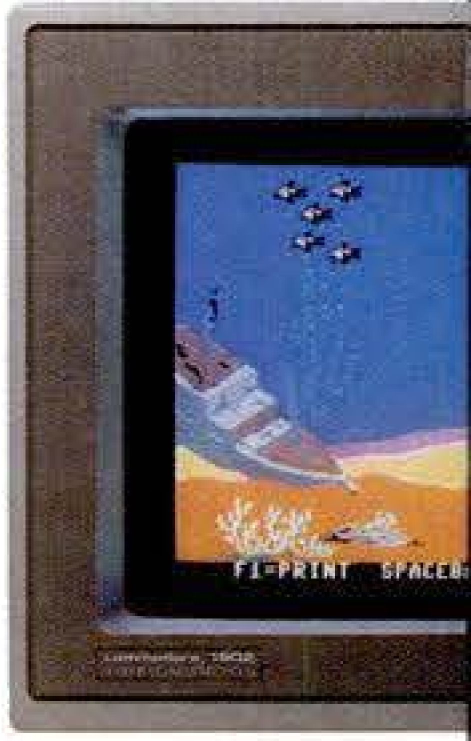
compose a song

paint a picture


do your banking

learn to fly

organize a data base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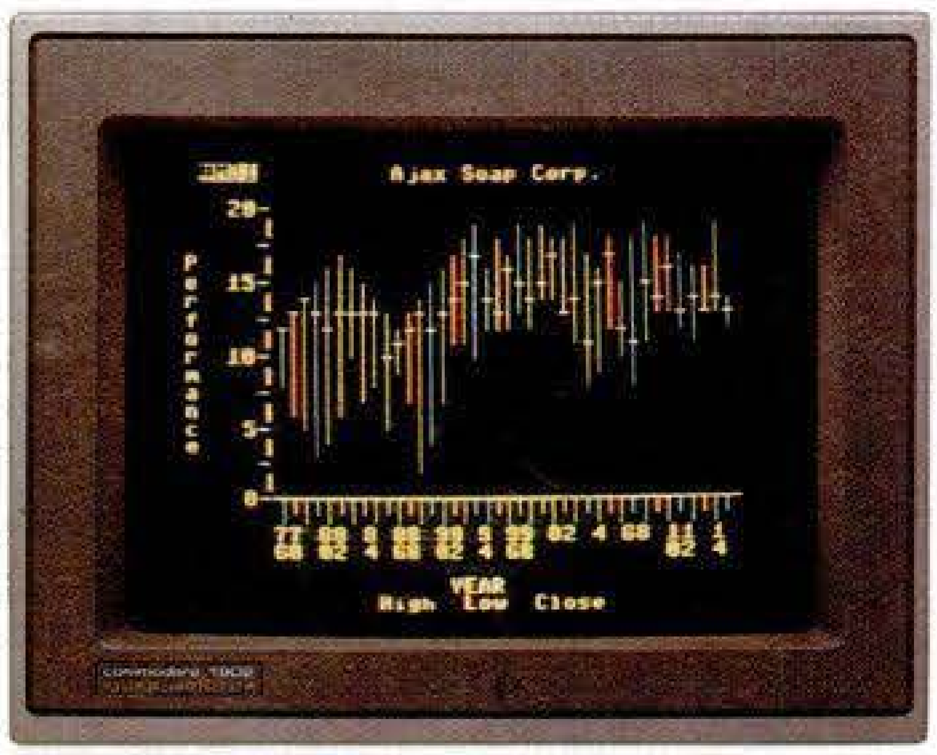
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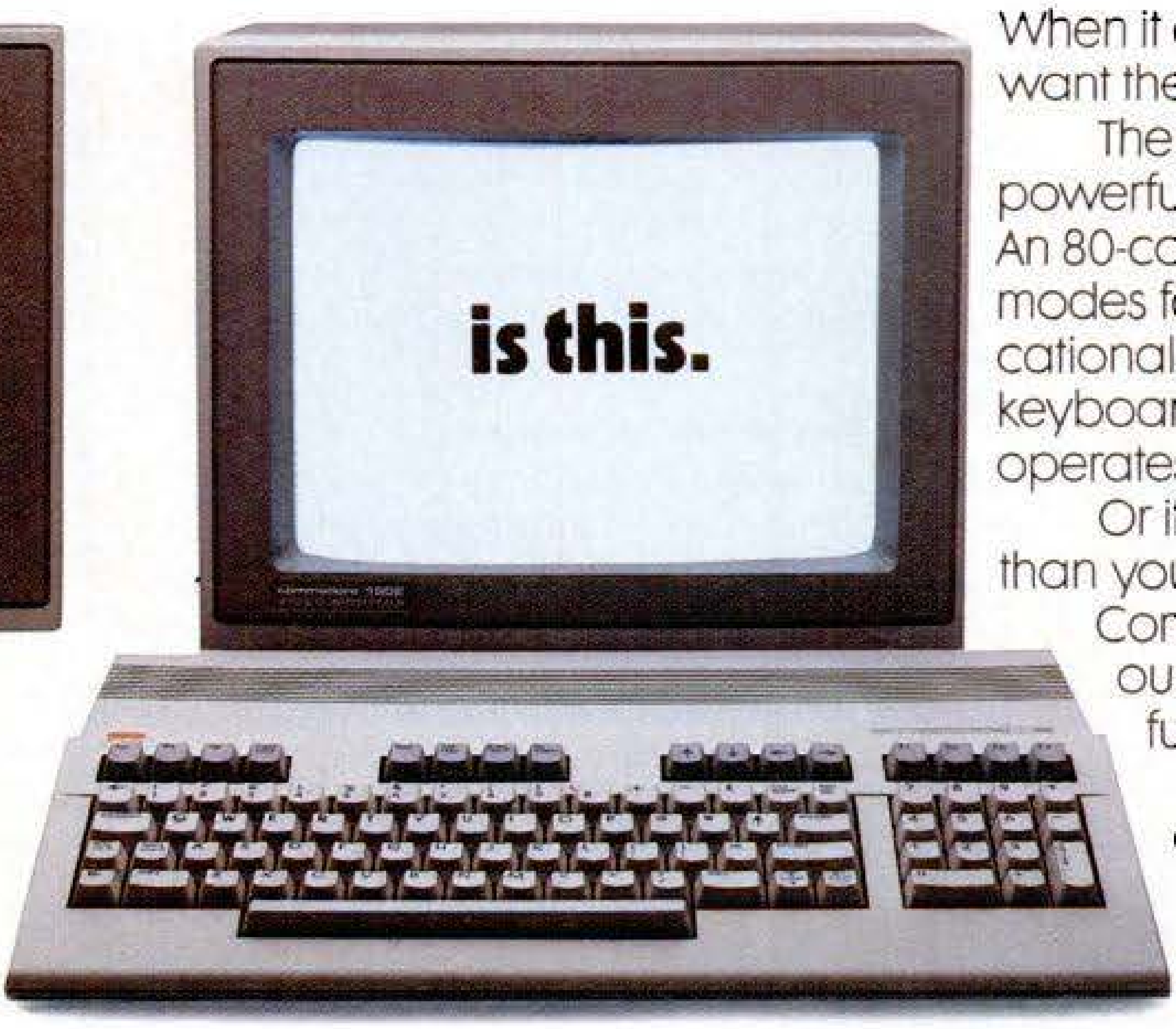

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COMMODORE 128 AND 64 PERSONAL COMPUTERS
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What's News

Gasoline is something we all use everyday. But it's not all the same. And, it turns out, there is a developing controversy over just what standards gasoline should meet, especially when it comes to the important quality called volatility. The controversy revolves around the fact that volatility has been creeping upward because of many interrelated problems. National surveys show that average volatility levels are well within current standards. But it is growing clear that the auto companies would be happier if the standards were lower and volatility were back at its old level of some years ago.

It's a complex, controversial story, though not well known at this time. And even less generally understood is the fact that the issues involved here can affect your car's drivability and other characteristics. You can learn all the details in the piece beginning on page 72 in this issue.

Mobile Americans

Figures just in show that Americans traveled 2.97 trillion miles in 1984—an average of 34.4 each per day—and spent $4,068 each doing it. That works out to an average cost of just over 32 cents a mile. We did 91 percent of the traveling in cars and trucks, the other nine in planes, trains, and on roller skates and pogo sticks.

The numbers come from the annual travel survey commissioned by the Hertz Corp. According to the survey, not all travel was for business and getting to and from work; 106 million adults took an average of 5.25 vacations or pleasure trips lasting from a weekend to two weeks or more. In the process, we averaged more than 7,000 miles of vacation travel each—more than a quarter of all mileage run.

Wood-powered bomb

More than a decade ago, with the Arab oil embargo in effect and the country's energy future in doubt, self-reliant Vermonters had an idea. With four-fifths of the state blanketed in forests, they said, why not build a wood-powered electric generating plant? Just over a year ago, the $70-million station went into operation.

It is not an outstanding success. It has sparked two rate increases totaling 32 percent, and is running at half the projected load factor. It generates power at a cost of 7.4 cents per kilowatt hour, while the utility is able to buy power from a New York utility for one cent and another Vermont utility for three cents. Yet the company isn't thinking of shutting down; for one thing, the city of Burlington is paying $9 million a year in annual interest payments and has to keep the plant running.

What happened? "We're right where we expected to be," says Cley Tewksbury, assistant plant superintendent, "but the world has changed." The two main factors: The price of oil has come down sharply, and former predictions of just how much power would be needed turned out to be too high.

Supersmart cards

It's the size and thickness of a regular credit card, but contains a microprocessor with 64 kilobytes of memory. It's being developed by Visa, and may be issued for testing within two years. It is, of course, the latest in the line of smart cards [PS, July '83]. You'd punch in your private identification number to use the card, ruling out fraudulent use. The card would contain detailed information about your account, including your credit limit, the amount of credit used so far, and so on. Thus it would be unnecessary for the retailer to call the company for a credit OK. Visa expects some version of such a smart card to virtually eliminate credit-card fraud.

Meanwhile, the Japanese have even more ambitious plans for smart cards. Ultimately, hopes the Posts and Telecommunications Ministry, every Japanese citizen will carry an all-purpose smart card that would do everything from charging purchases to getting cash from the bank to storing medical records that would be instantly available in an emergency. One Japanese newspaper, with appropriately poetic style, called it the "card of 10,000 abilities."

Solid/fluids ready to move

The group of British scientists who developed the so-called electro-rheological fluids have left Sheffield University and set up a private firm aimed at commercial development of the unusual and fascinating substances. ER fluids [PS, April '84] change from a liquid to a solid when subjected to an electrical voltage. Further, they don't change all at once, but gradually—the higher the voltage, the stiffer the fluid.

This strange phenomenon has many potential applications. For example, one firm is working on ER shock absorbers. Since ER fluids can change from liquid to solid in a half millisecond, a changing electrical voltage could tailor shock-absorber response to road conditions faster than anything now available.

Other companies are working on electronic clutches in which a disc might rotate in a bath of fluid. With increasing voltage, the fluid would stiffen, soon giving 100-percent coupling between the two. A similar plan is being developed to give positive lockup and greater fuel economy from automatic transmissions. The promise is great; the company says it now has joint ventures going with some 60 companies worldwide, a dozen of them in the United States. Half involve vehicle development.

CPGilmore
Editor-in-Chief

How new "eyes" track the mysterious origins

For more than 70 years, astronomers and physicists have puzzled over the nature and origin of the most energetic radiation known—cosmic rays. These particles bombard Earth from every direction. Now two sophisticated new detectors—the Fly's Eye and the Chicago Egg—may help solve the enigma.

By DENNIS MEREDITH

I'm standing in a forest of huge metal cans, clustered atop an isolated, weather-beaten hill in southern Utah. Physicist Peter Gerhardy flips a switch on a control box, and a small motor whines to life, ponderously rotating one of the large corrugated culverts upward to its stand. To a casual observer, the array of 67 metal drainage pipes might look like parts in an abandoned construction site, but they house the "retinas" of the most sophisticated ground-based cosmic-ray detector in the world. It is the Fly's Eye, built and operated by the University of Utah. Completed in 1980, the eye explores one of the most startling phenomena in astrophysics: the bombardment of Earth by high-energy particles far more powerful than any that humans can create in particle accelerators.

Cosmic rays have been studied since 1912, when Austrian physicist Victor Hess made balloon flights with crude detectors to a maximum height of about 16,000 feet. He found that the higher the altitude, the more powerful was a mysterious kind of radiation that had been puzzling observers for years. This was evidence that whatever was causing the radiation came from outside the atmosphere. American physicist Robert Millikan confirmed that notion in the early 1920s, and the extraterrestrial somethings came to be known as cosmic rays.

Today, astrophysicists know that cosmic rays are primarily atomic nuclei—atoms stripped of their electrons. Nuclei of every element, from hydrogen through uranium, have been detected, but most are simply protons, the nuclei of hydrogen atoms. A steady stream of relatively low-energy particles cascades down from space, only to be blocked by Earth's atmosphere. But occasionally, baffling high-energy particles, mostly protons, with energies ranging up to 100 billion billion electron-volts, plow into Earth's atmosphere at enormous speeds. Each of these particles carries enough energy to lift a kilogram mass almost 10 meters (33 feet)—enough to split atoms in the atmosphere, creating showers of elementary particles that survive to reach the surface.

Cosmic-ray theories

Despite 70-odd years of study, scientists have no real explanation of the particles' origins, or what mechanism accelerates them to such enormous energies. Some theorists speculate that the particles are remnants of long-dead stars, spewed out in the giant stellar explosions called supernovas. Others suggest an origin in titanic shock waves rolling through space dust, or in the motion of the spinning, superdense stars called pulsars. Solving these mysteries could, most astrophysicists believe, reveal much about the birth and death of stars and the nature of the galaxy itself. Now, results from the Fly's Eye and data from the Chicago Egg, a new detector launched in July aboard the *Challenger* space shuttle (and made powerful by the accidental discovery of the unique properties of ski-jacket fluff) may begin to unravel the puzzle.

On the Utah hillside, Gerhardy stops the rotation of the can part way, and we duck beneath the edge of the culvert to see the instruments within. The first thing I notice is the 62-inch concave mirror mounted at the other end of the huge cylinder.

"The mirror makes a great solar collector," says Gerhardy, "so we have to keep the array turned downward during the day—otherwise the instruments would be fried." The instruments are an array of 14 light-detecting photomultiplier tubes mounted at the mirror's focus and aimed at it.

On this moonless night, explains Gerhardy, after the sun sets, the Fly's Eye computer will automatically rotate the cylinder and its 66 mates to peer up at the night sky. Ten at a time, the cylinders will be brought into position over a period of 20 minutes, and after a system checkout by the computer, the large array will be ready for another night of observation. With each cylinder aimed at a different section of the sky—like the multifaceted compound eye of a fly—the array can monitor a huge expanse.

Two-and-a-half miles away is a second installation, Fly's Eye II, with 36 mirrors. The two eyes will wait for the faint streamers of bluish light that represent cosmic rays streaking through the atmosphere, exciting nitrogen atoms in the air to fluoresce.

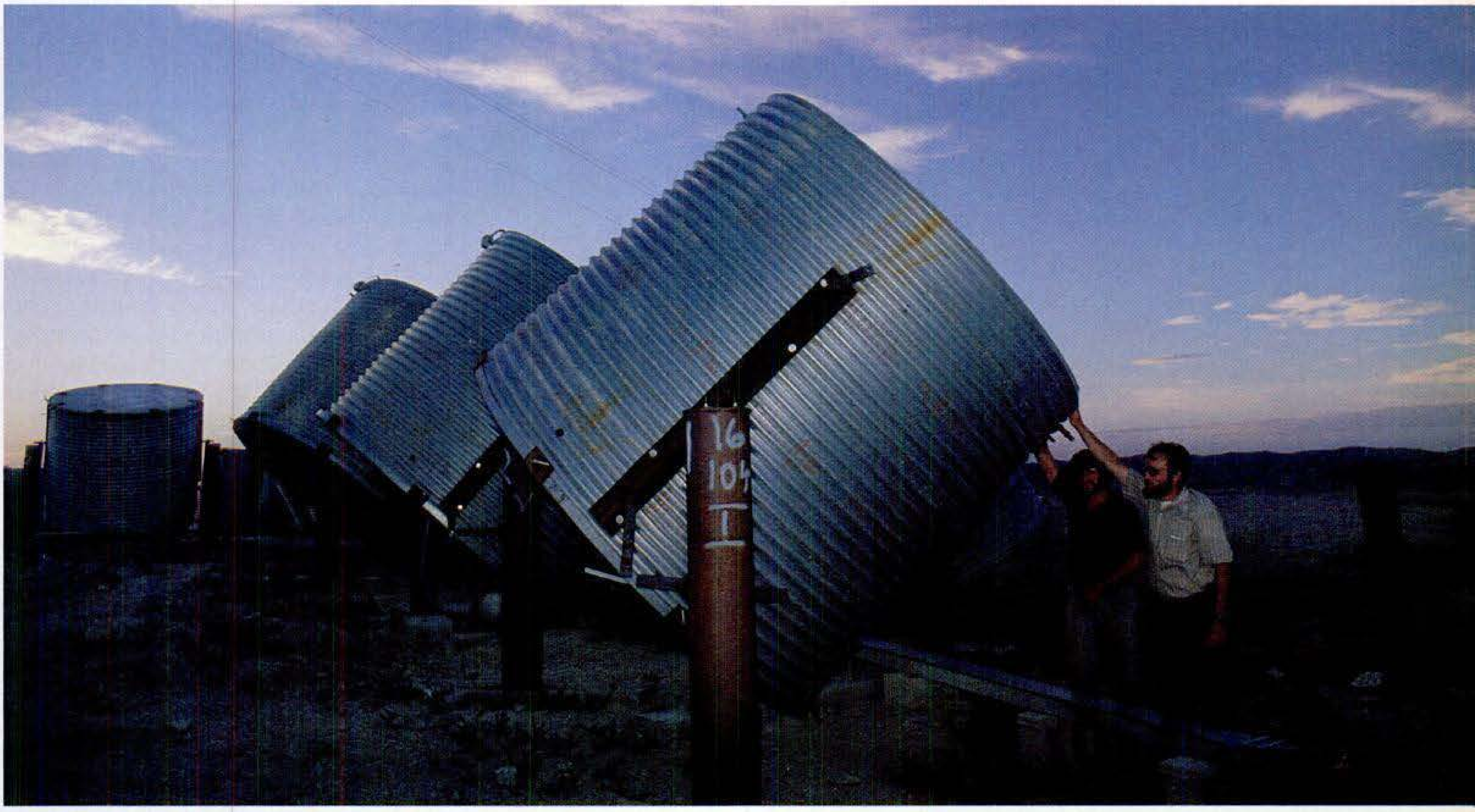
Although the Fly's Eye is basically a collection of wide-field telescopes, the sophisticated computer controlling these telescopes knits the system into one powerful instrument. Each facet of the eye contains its own electronics, built to respond to the unique cosmic-ray signals.

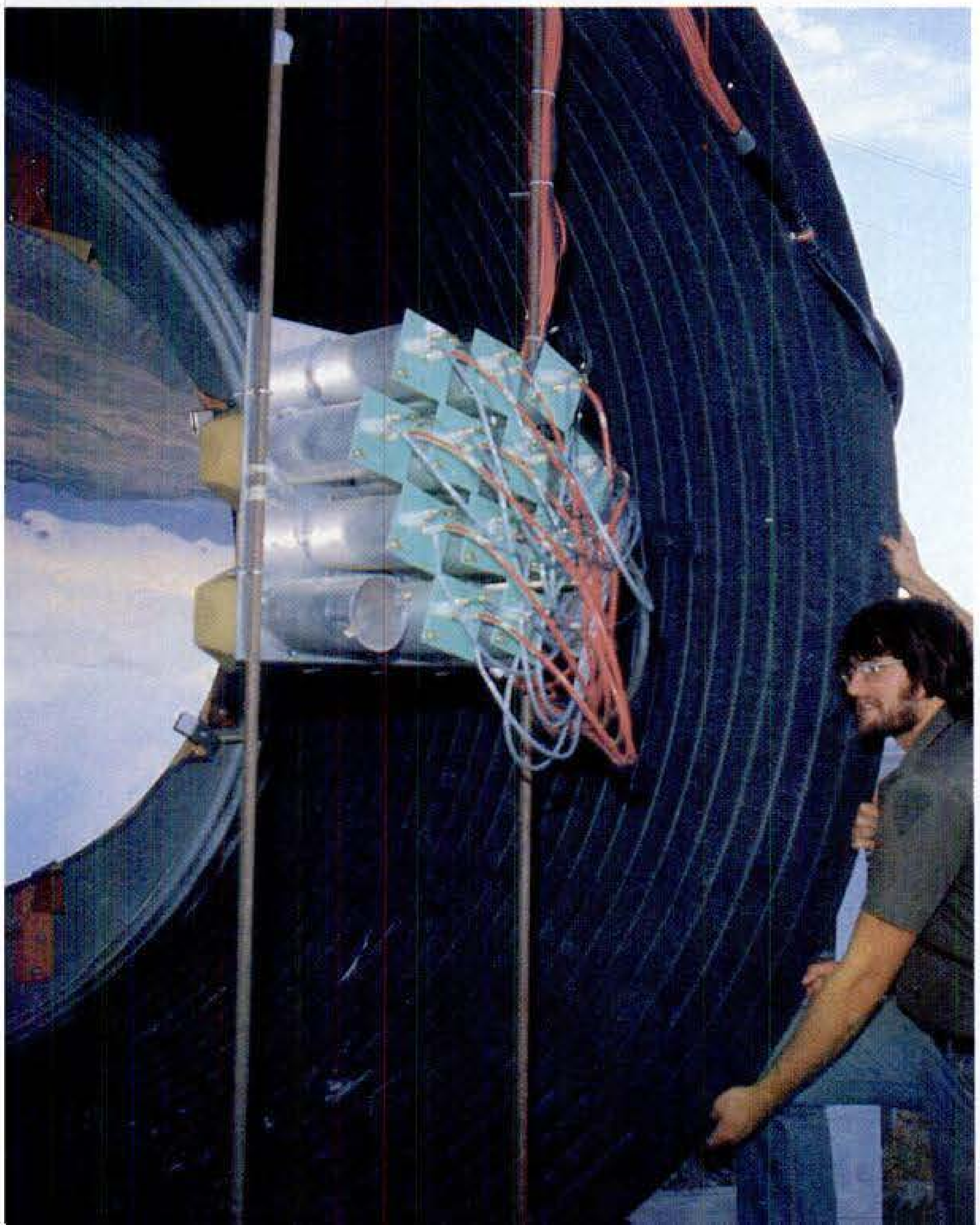
Picking out the cosmic-ray signal from the background is no easy task. As one of the project leaders, George Cassiday, puts it: "Consider a blue five-watt bulb streaking through the sky at the speed of light against a continuous backdrop of starlight, atmospheric airglow, and man-made light pollution. In addition, sporadic sources of light such as lightning, auroras, airplane and smokestack strobe lights—visible for hundreds of miles—create a certain visual havoc."

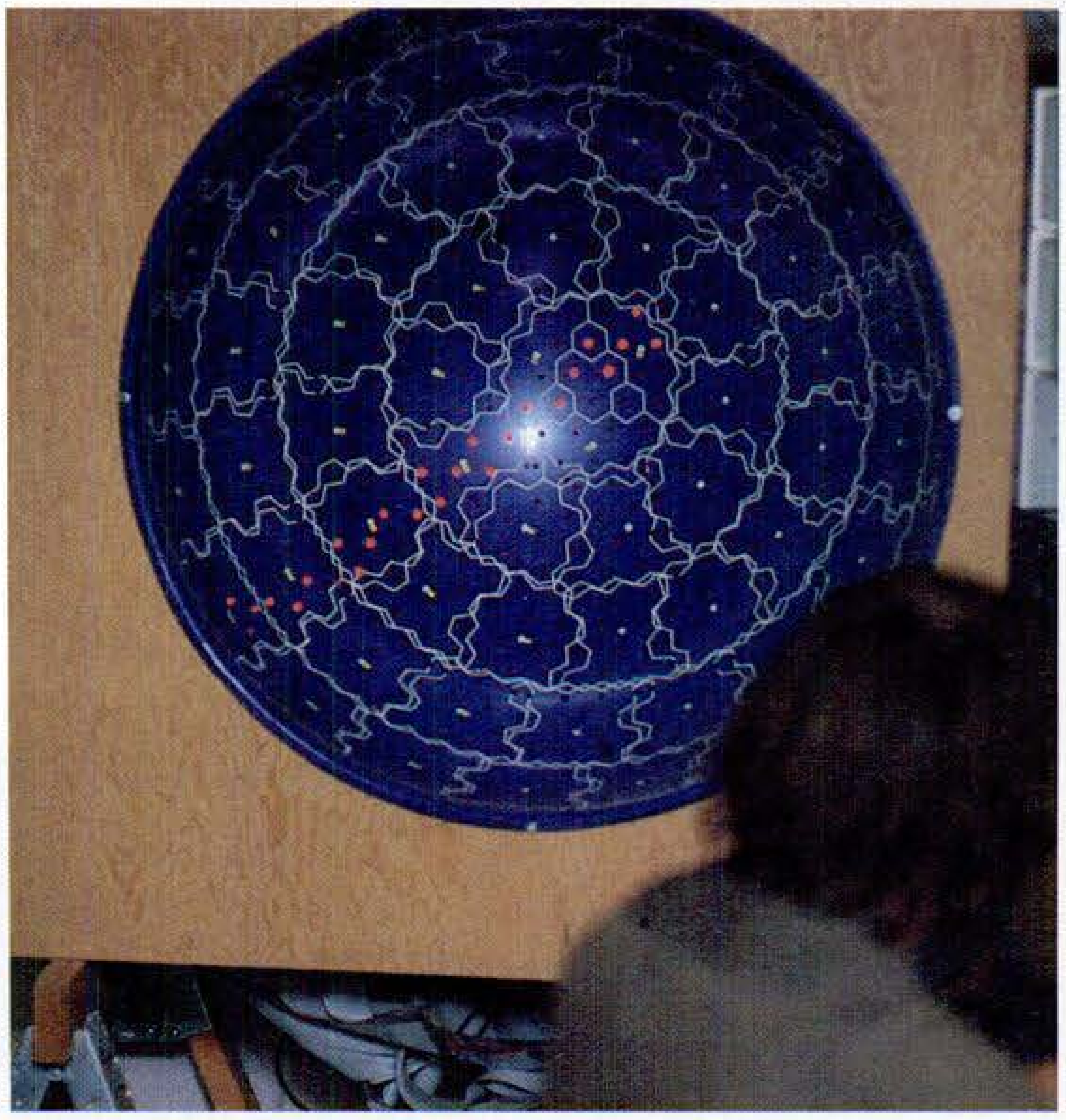
Despite this confusion, and in the face of icy winters and blistering summers, the Fly's Eye has worked marvelously. Back in the equipment-stuffed control hut, Gerhardy and Cassiday show me what the eye had seen the night before. Their display is a large hollow hemisphere, studded with red LED lights, each represent-

Continued

# of cosmic rays







University of Utah's Fly's Eye cosmic-ray detector is an array of metal drainage pipes (top), each housing a 62-in. concave mirror with a bundle of light-detecting photomultiplier tubes mounted at the focus (left). Cosmic-ray signals trigger red LED lights on a spherical display (above).

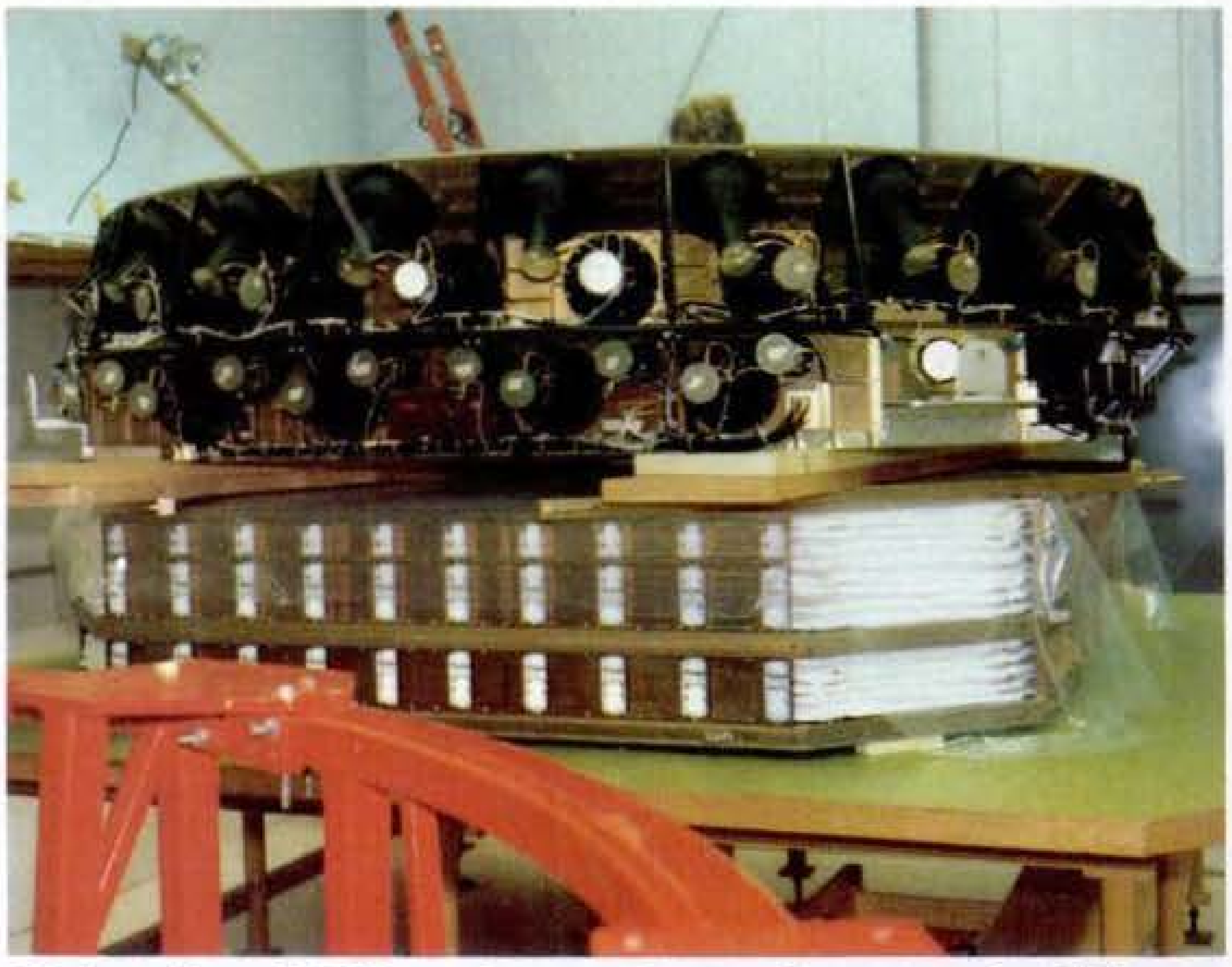
ing the output of one photomultiplier. Gerhardy enters a request on the computer terminal, and abruptly a trail of light skitters across the display. The trail splits into several separate trails at the end, marking the showers of secondary particles.

Then Cassiday and Gerhardy show me the kind of data that have yielded a hint of where high-energy cosmic rays could come from. Instead of a trail of LEDs, they show me a "hit" represented by a single pulse of light coming directly at the mirror.

"This is what we get when we run in 'blast' mode," says Gerhardy, "which means that the computer is set to accept the light entering detectors on one mirror." Those single pulses of light represent not cosmic rays exciting nitrogen atoms but the much fainter Cerenkov light from gamma rays—the most energetic electromagnetic waves—seen head-on by one of the telescopes. This Cerenkov light is produced by electromagnetic interaction of the gamma rays with the atmosphere. Cerenkov light is much fainter than the light produced by cosmic rays and is beamed in the ray's forward direction. If seeing cosmic-ray traces is like detecting the light scattered from a distant searchlight, seeing gamma rays is like detecting a flashlight beam; the only hope is to see the ones that come head-on.

What has intrigued cosmic-ray scientists is that the Fly's Eye has detected gamma rays coming from particular objects in the sky. Such gamma rays reveal the presence of extremely high-energy processes in the objects that emit them.

Until now, scientists have been un-



University of Chicago's cosmic-ray detector, the Chicago Egg, is checked before shuttle launch (top). Stacks of octagonal blankets made of polyolefin fibers (above) detect high-energy particles. With protective covering (right), the egg is lowered into *Challenger*'s cargo bay, shown in space with other scientific instruments (opposite page).

able to even begin to pinpoint cosmic-ray origins because the particles are deflected into a confusing swirl by the galaxy's magnetic fields. But, says Eugene Loh, another Fly's Eye project leader, gamma rays are another matter. "High-energy gamma rays are not deflected by magnetic fields," he says, "so by getting hold of a gamma-ray source, we can tell that we have identified a source that definitely produces high-energy particles. For the first time, we've seen a high-energy source that we think can produce high-energy protons because they, in turn, produce high-energy gamma rays that come straight down to us."

Cosmic companions

The most important gamma-ray source found by the Fly's Eye so far is called Hercules X-1. It is a pair of stars circling each other about 1.6 million light-years from Earth. One of these stars is a superdense spinning neutron star, called a pulsar, that sends out light in precisely timed pulses. Its companion is a normal star, and as the two circle one another, blobs of matter from the companion fall onto the pulsar, causing periodic bursts of X-rays.

During several runs, the Fly's Eye detected large amounts of gamma rays coming from Hercules X-1. This alone would be enough to peg Hercules X-1 as a possible source of cosmic rays. But X-ray studies of the binary system gave scientists even more hints that the companion-star system is a source of cosmic rays.

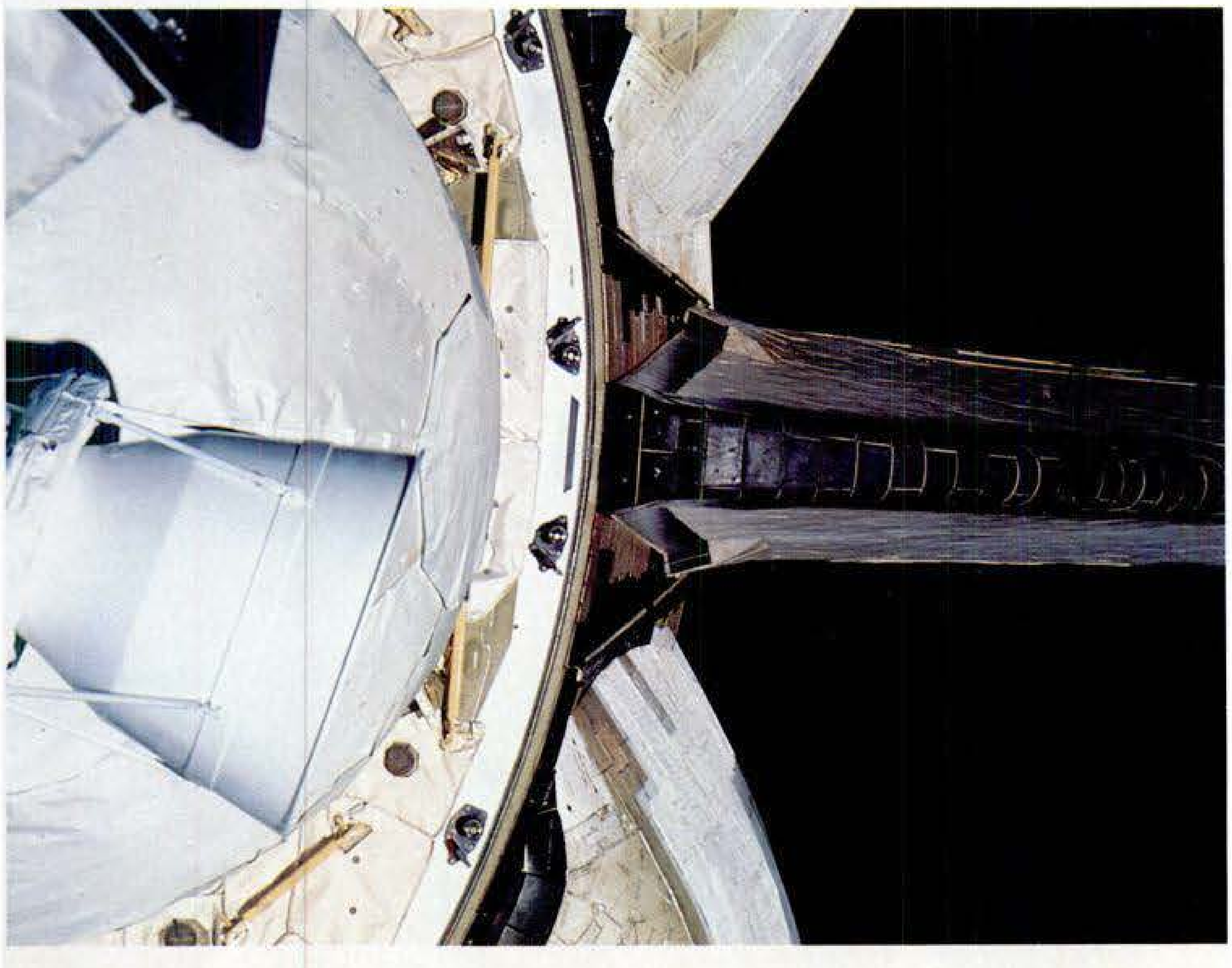
"At the same time we were looking at it with the Fly's Eye, other scientists were looking at it with X-ray and optical telescopes," says Utah physicist Jerry Elbert. "They didn't see large amounts of X-rays from the pulsar, even though they should have seen several bursts during that time. However, optical studies showed a brightening that did indicate X-rays were being made and were bombarding the companion star, heating it up.

"We think some matter may have been blocking the X-rays from reaching us, and that it may have been a disc of material around the pulsar, called an accretion disc. It may be that the high-energy protons being produced by the pulsar were striking the material, producing the burst of gamma rays that we saw."

Hercules X-1 is not the only pulsar system that has proved to be a gamma emitter. Scientists in West Germany and England have found that the system called Cygnus X-3 is a similar gamma-ray source. Such discoveries mark only a beginning, and cosmic-ray theories abound.

"All these theories are not on terribly solid ground," says University of Chicago physicist Peter Meyer, "but they are much, much better than what they were ten or fifteen years ago." Meyer and his colleague Dietrich Müller have taken the next major step in cosmic-ray research. Last July, their gigantic detector, nicknamed the Chicago Egg, was launched into orbit aboard the space shuttle *Challenger* to determine, for the first time, what cosmic rays are made of. Although high-energy cosmic rays are mostly protons, they are "flavored" with other elements, and this flavoring could be an important clue to their origin.

The 1.5-ton Chicago Egg rode into orbit nestled in the back of the shuttle cargo bay, where it successfully collected signals from high-energy particles. Computer analysis of the data will take two years.



Müller and Meyer showed me the egg under construction at their Chicago laboratories. It consists of three kinds of detectors stacked atop one another, each with a specialized job. The rounded ends of the 12-foot-long egg are large hemispherical Cerenkov detectors filled with a neon-CO_2 mixture. These detectors are ideal for precisely measuring particles with energies from about 50 billion to 150 billion electron-volts. Inboard from each of the Cerenkov counters are layered sheets of plastic that fluoresce when struck by high-energy particles. These sheets will do the basic job of identifying the particles that stream through the detector. Light-detecting phototubes surrounding the two detectors provide the signal.

But it's the third kind of detector—the one that detects the highest-energy particles—that's really revolutionary. On my visit to their laboratories, Müller and Meyer showed me large piles of octagonal blankets made of a cottonlike substance. Six stacks of these blankets will enable the detector to sense cosmic rays between 500 million and a few trillion electron-volts. The stuff was a surprising invention, even to the inventors.

Because of the shuttle's weight limitations, the scientists couldn't use tungsten or iron detectors, which physicists normally build to catch high-energy particles. Such an instrument, for their purposes, would have weighed 30 or 40 tons.

So the Chicago scientists decided to use what are called "transition-radiation detectors," based on previous research by Müller. Transition radiation in the form of X-rays is emitted when particles of superhigh energy enter or leave materials with different electrical properties. Such a detector is an ideal means for measuring superhigh-energy cosmic rays. But figuring out how to build one big enough was frustrating. For one thing, to give a measurable signal, the instrument would have to be made so that each cosmic ray zipped in and out of the detector material thousands of times.

Ski-jacket saga

"We originally proposed constructing a sandwich of about 10,000 layers of Mylar film, each spaced precisely about thirty-millionths of a meter apart," says Meyer. "We might have done it, but we would have all ended up in an asylum." Keeping such a

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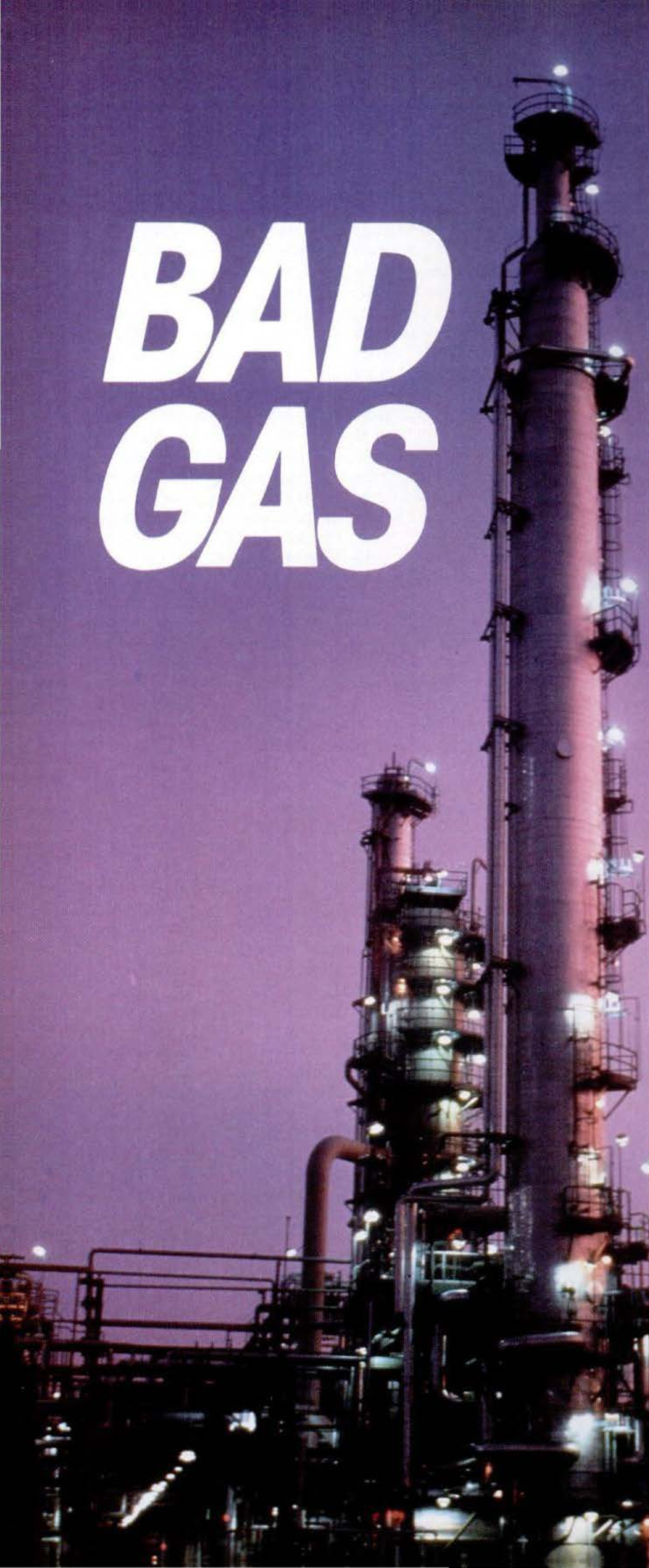
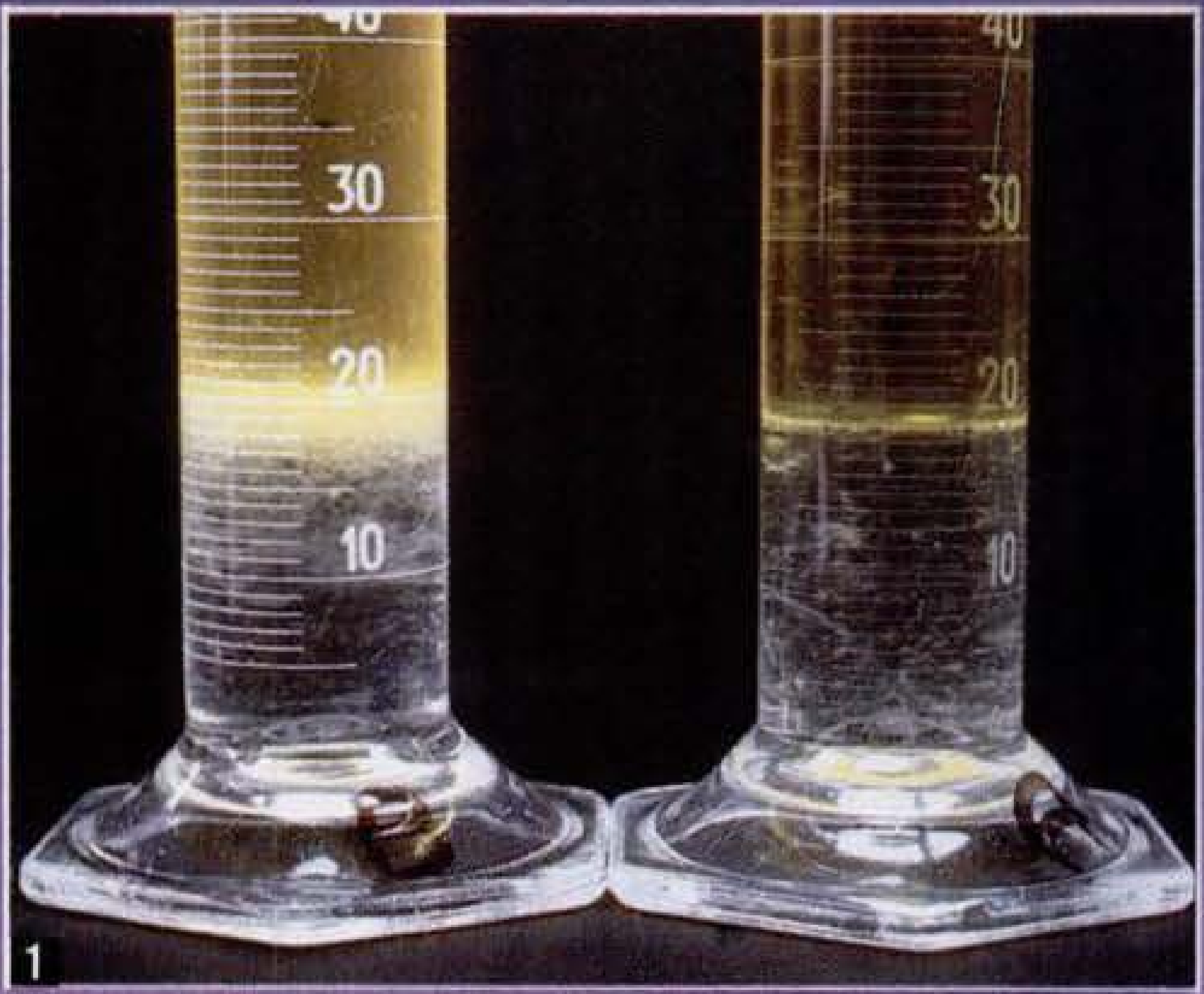
BAD GAS

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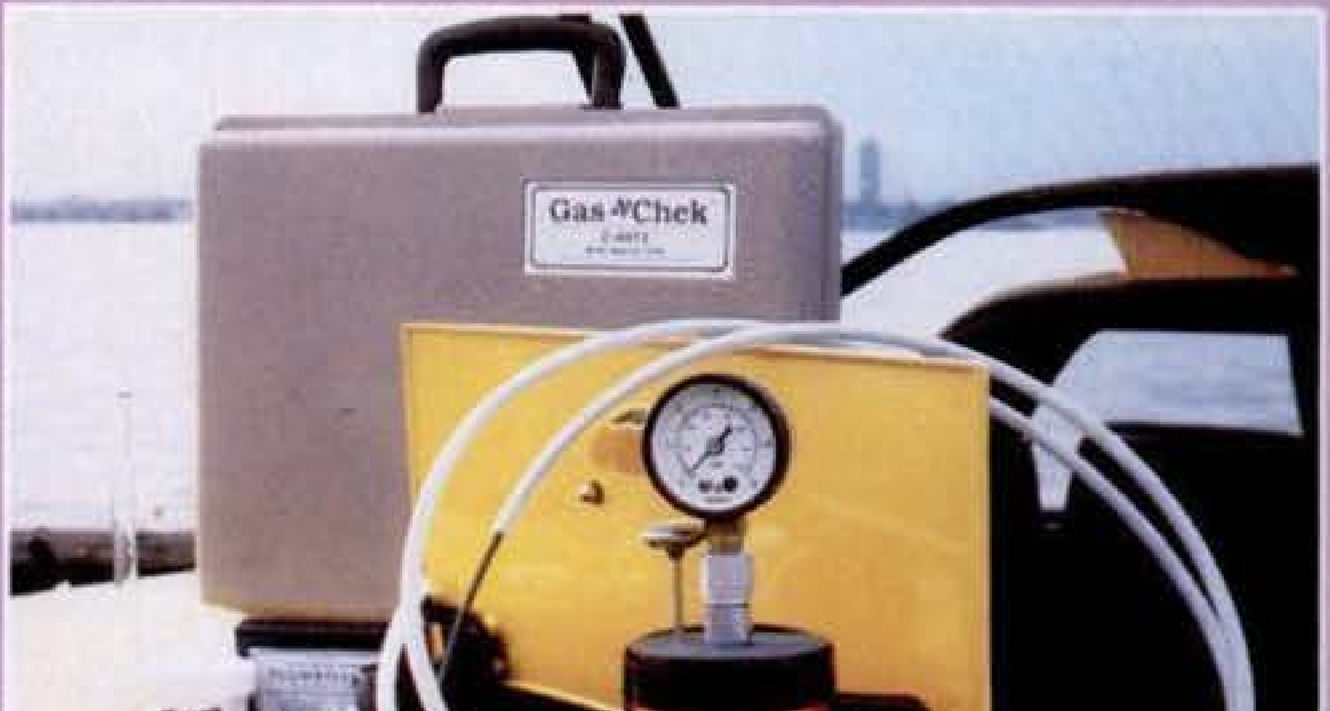


4

Changing gasoline quality is behind some of the poor performance and drivability problems drivers complain about, and it undoubtedly has caused unnecessary repairs. Auto and oil companies don't agree on the best way to solve the problem. But you can minimize your troubles if you know what to look out for.

By JACK KEEBLER

Gasoline quality is changing.

- A characteristic engineers call vapor pressure has been rising for several years. Auto-company experts say this causes vapor lock, fuel foaming, hot-starting problems, unstable idling, and more.
- Alcohol added to gasoline, while defended by some authorities, is condemned by others. They charge it produces drivability problems and, in some cases, possibly damages parts in the fuel system.
- Detergency of at least some gasolines seems to be falling, producing clogged fuel injectors and carburetors.

Just how bad is the situation? It depends on who you ask. The most outspoken representative of the auto industry is Gil Clark, a fuel specialist at Chrysler. "Changes in gasoline quality," he says, "have never been more significant—or more troublesome to the motorist—than they have become in the last three years." Others have a different opinion: "In general," counters C. B. Hood, manager of fuels technical services at Mobil Oil Corp., "motorists are getting the best gasoline buy ever. All gasoline isn't the same, but gasoline quality overall is the best it's ever been, and that's certainly true so far as our company is concerned."

Where does the truth lie? As is often the case, the situation is both controversial and complicated. Certainly, most of the gasoline sold today, particularly that blended by the major oil companies, meets industry standards. It's the standards that need to be changed, counter the auto-company experts. Then there's the really bad gas—gas that is improperly and in many cases illegally blended. No one knows how much of it is being sold. This is the stuff that can really get you into trouble. To get at the facts, I interviewed engineers at major auto and oil companies and talked to independent experts. Here's what I learned.

What's happening and why

Gasoline is not a single substance, but a mix of scores of hydrocarbons—molecules made of hydrogen and carbon. They range from light, volatile substances to heavy, less volatile ones. An ideal fuel is balanced; it has low vapor pressure—a high boiling point—to avoid vapor lock, but enough volatile elements for easy starting. Petroleum companies vary the blend constantly. Winter gasoline, for example, is more volatile than summer gasoline for easier cold-weather starting.

Car manufacturers feel that the biggest problem today is volatility's upward creep, especially in the summer. It would seem to be an easy problem to solve: Simply blend a less volatile mix. In principle, that's true. But a complex web of economic, legal, political, and engineering considerations are conspiring to push gasoline's volatility up rather than down.

Volatility is measured in terms of vapor pressure. Vapor pressure quantifies a given fuel's tendency to vaporize—to turn from a liquid to a gas. It is measured by what engineers call the Reid vapor-pressure (RVP) test. One expert who spends a lot of his time studying trends in vapor pressure is Chrysler's Gil Clark. Clark describes himself as an evangelist, and he looks and sounds the part.

He showed me what the RVP test is all about. You start by chilling both a small brass container and a gasoline sample down to about 30 degrees F. "Then you completely fill the chilled chamber with the gasoline," he says in his soft Texas twang, "and screw it onto the bottom of a brass tube with a pressure gauge at the top. Now you have captured a sample of gasoline in a closed container with a vapor space above the chamber. Next you drop the whole assembly into water at a hundred degrees, and wait fifteen or twenty minutes while it all comes up to temperature. During that time some of the gasoline vaporizes and the pressure in the tube rises. Then you simply read the gauge."

That number—it used to be about nine in summer and 12 in winter—has been creeping up. Why is that important? Clark explains: "You pull off the freeway on a hot day to pick up a loaf of bread on the way home. The car is nice and hot, and in the five minutes you're in the store everything under the hood gets a hot soak. You come back, hop in, start the car, and head out. It will start and run across the parking lot, where the fuel demand is low. But the hot gasoline began to boil while you were in the store. It makes so much vapor that the fuel pump is windmilling full of vapor and not delivering enough liquid fuel. When you try to accelerate to reenter the traffic stream, the engine dies lean [is starved for fuel]."

The opposite can happen. "Some cars now have fuel pumps with sixty to eighty times the pumping capacity needed for constant speed," adds Clark. "In this situation, hot fuel instead of just vapor will reach the high-temperature environment under the hood and foam just like shaken soda pop. That fuel bubbles out of the bowl vent, falls into the carburetor, and causes the engine to run rich. Fuel foaming is a brand-new symptom that has just been recognized in the last few years as fuel volatility has crept upward."

The situation can be serious. Last June, a load of winterized, or high volatility, gas was shipped to Albuquerque, N.M. "Stalled cars were lined up as far as the eye could see," says Sandy Brady of Albuquerque's Better Business Bureau. "The worst time often comes on a unusually warm day in spring," says Robert Everett of GM's emissions-control staff. "Winter gas is still in the pumps, and

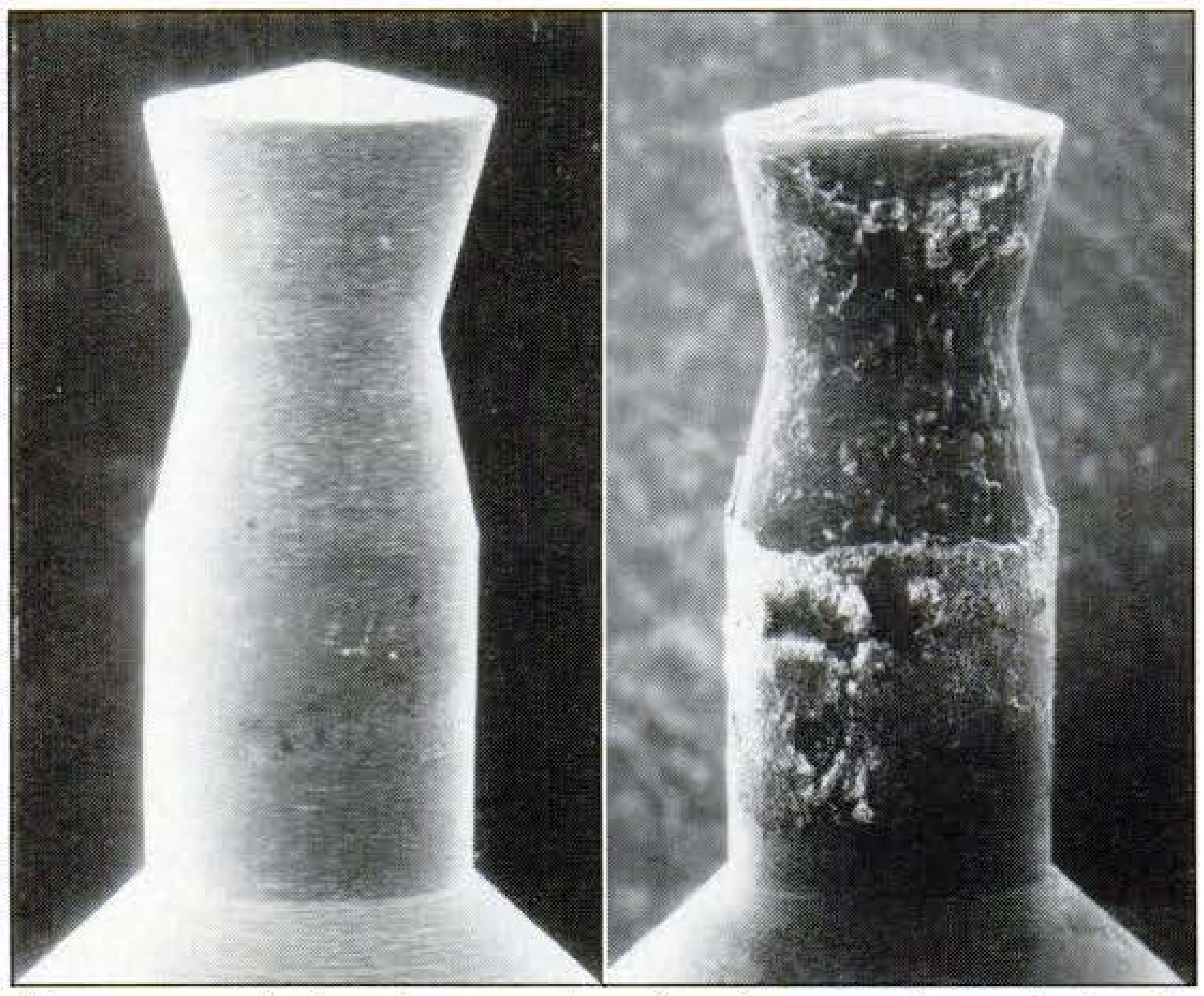
Continued

Like a ghostly sentinel, the fractionator tower of Mobil Oil's new alkylation unit (facing page, 1) looms on the nighttime horizon. Improperly formulated fuel detergents can create problems. In the top right photo (opposite) a soapy emulsion (2) has formed in the graduated cylinder on the left. Fuels without detergents can lead to fuel-injector plugging (3). The injector photo on the left shows a good injector with a healthy spray-cone pattern. On the right is a partially plugged injector. Poor cylinder-to-cylinder fuel distribution and inadequate vaporization can result in reduced engine performance and higher emissions. Gasoline buyers with sufficient curiosity and $150 can purchase a Gas Check kit from Miller Special Tools. The kit measures water content, alcohol percentage, vapor pressure, and the presence of lead in unleaded fuel. Tools for doing the tests come in a plastic carrying case.

cars are stalled all over the expressways. The problem for us is that those customers don't recognize the fuel-volatility problem. They blame the car."

And it may even cause unnecessary repairs. "If you spend an hour on the side of the road with your stalled car," says Clark, "the problem will cure itself as the car cools down, and you'll eventually be able to start again. But if you're unlucky enough to get a tow truck in a hurry, you'll be towed to the nearest garage where the mechanic may want to replace all of the pieces of the fuel system he can see. I heard of one fellow who had his fuel pump replaced seven times when the real problem was the gasoline supply."

Despite such stories, is the problem really serious? While some auto people claim it is, oil-industry experts take a different point of view. "Late-model cars," says Hood of Mobil, "are less sensitive to gasoline volatility than their predecessors. Many have fuel pumps in the fuel tank, making them less sensitive to vapor lock. Many individual cars may still be sensitive to vapor lock and other volatility problems because of one or more defects such as a misrouted fuel line, missing insulation, or a marginally defective cooling system." And Jim Smith, an Amoco Oil Co. product engineer, adds flatly, "The only time customers experience problems with vapor lock is during the summer. And these instances are fairly rare except with temperatures in excess of ninety-five degrees."


Above are photomicrographs of a clean and an obviously dirty fuel-injector pintle. A dirty pintle can seriously affect the injector's spray pattern (photos on previous page) and vehicle performance. The diameter of the pintle is about 0.8 mm (0.03 in.); the annular clearance between the pintle and the injector's barrel is a critical 0.05 mm (0.001 in.).

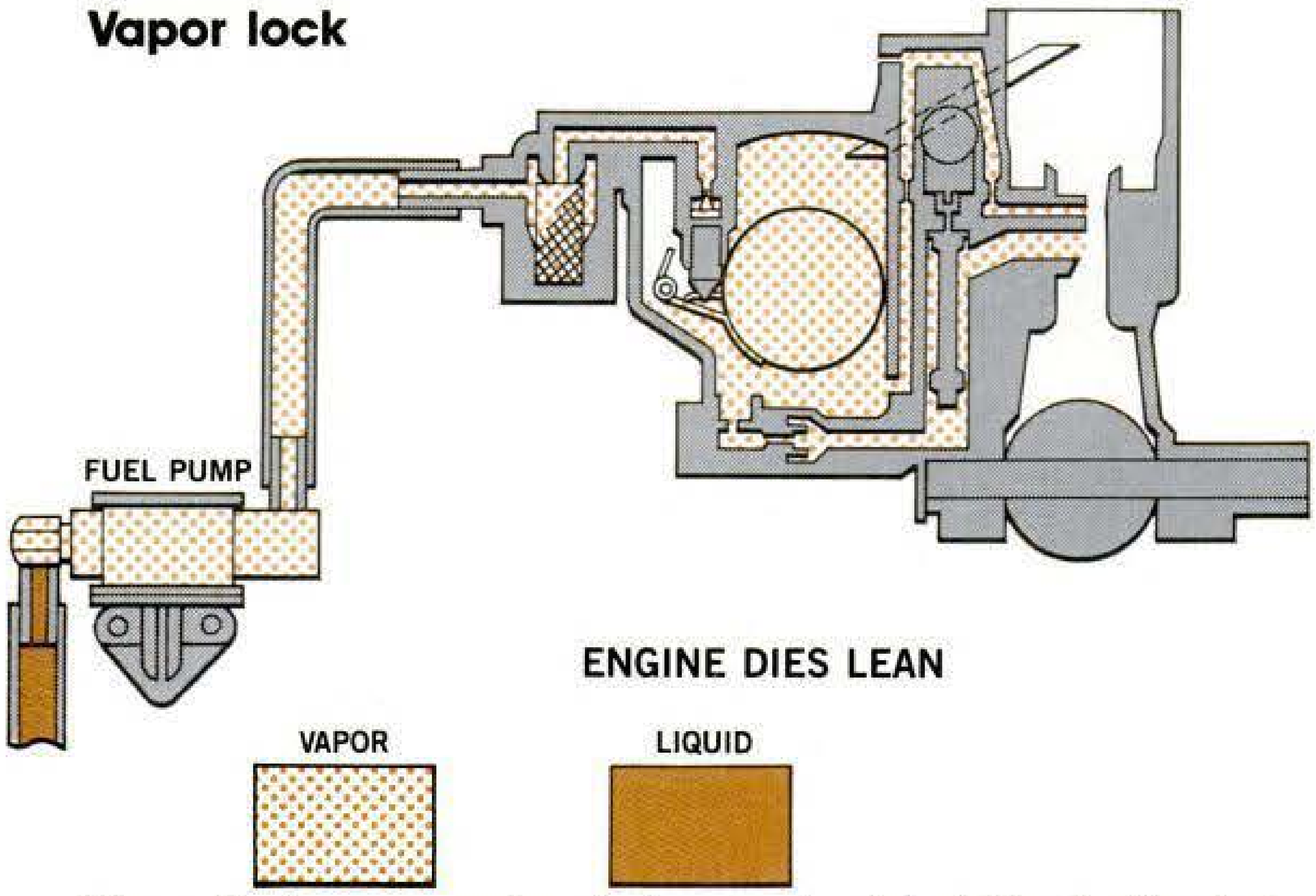
Why is volatility rising? The answer revolves around two fundamental facts: Crude oil doesn't contain the various kinds of hydrocarbons in the amounts they're needed for gasoline. For example, an average barrel of crude yields about 28 percent gasoline. The industry would like and could use 45 to 50 percent.

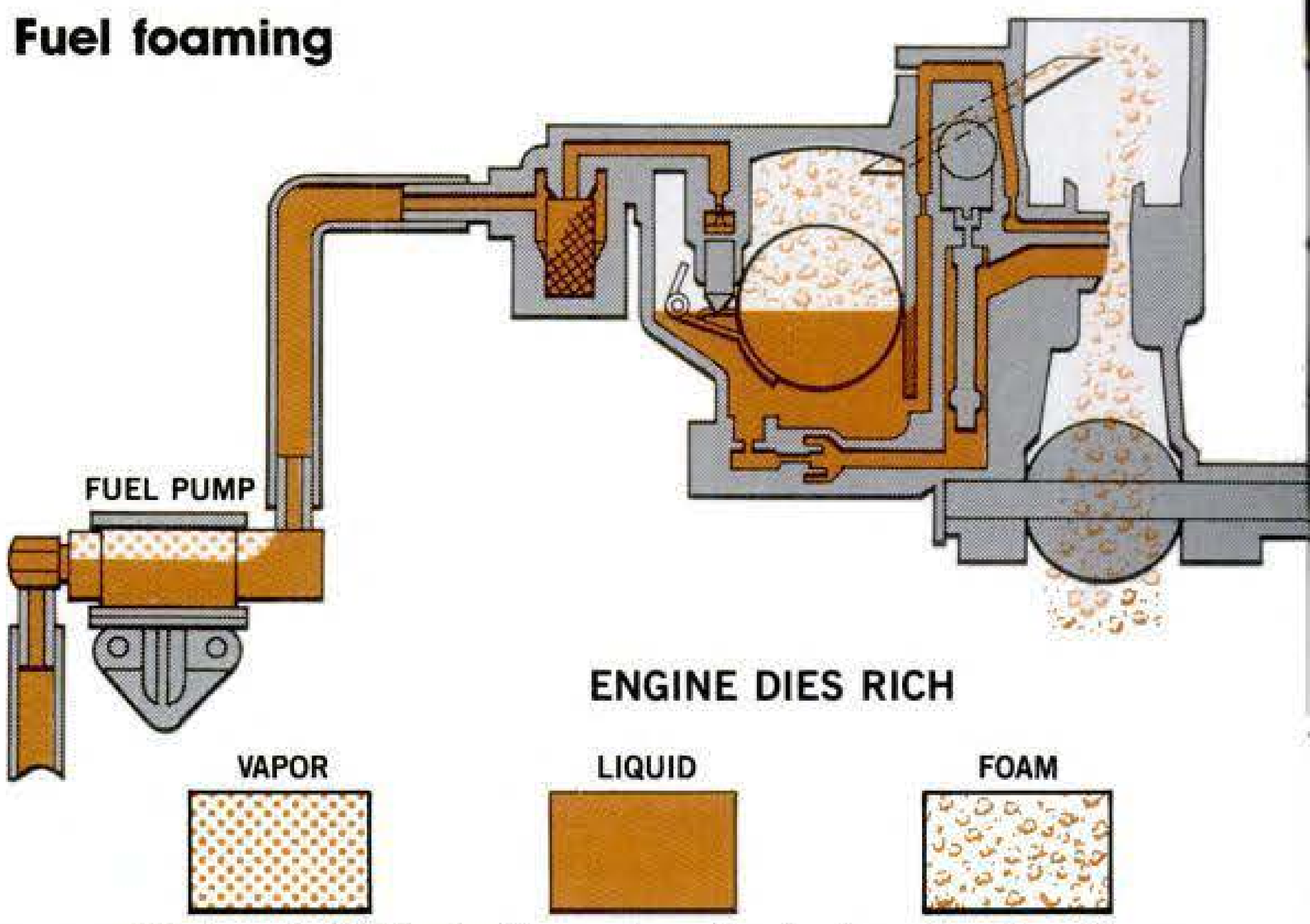
In addition, an engine fuel must have a sufficiently high octane for the engine in which it is to be used. Octane is a measure of a fuel's ability to burn smoothly and deliver power to the piston, rather than exploding suddenly and causing possibly damaging engine knock.

For decades, refiners added a substance called tetraethyl lead to gasoline to improve octane. But during the early 1970s, the Environmental Protection Agency (EPA) mandated that lead be removed from gasoline. That made the percentage of gasoline available from a barrel of crude fall further, since it didn't contain enough high-octane ingredients to make the whole mix satisfactory. So refiners turned to a refining technique called reforming—a process that combines certain light molecules to make more complex high-octane molecules.

Reforming is today's main octane-raising tool. It's not free, however: The higher the temperature and the longer it's held, the higher the octane—but the lower the yield. In fact, some 20 to 30 percent of the original is lost in the form of butane and other less valuable products. That's why unleaded gasoline costs more than leaded of a given octane.

Octane can also be improved slightly by adding butanes and a few other relatively cheap, light fractions. And that works right in with reforming. "Generally, the things that manufacture octane also manufacture higher-volatility components such as butane," says James De Jovine, manager of testing and refinery technology for Atlantic Richfield Co. "And butane, which has fairly high octane, is cheaper than gasoline. So to raise octane and at the same time make your product as economical as possible, you want to use butane to the fullest extent possible." Thus increasing octane also tends to increase volatility.





Vapor lock occurs when hot, vaporized fuel blocks the fuel lines. The fuel pump, designed to pump a liquid, windmills, starving the engine. Fuel foaming tends to strand owners of newer carburetor-equipped cars with high-capacity fuel pumps. High-volatility fuel reaches the hot under-hood environment and foams. This foam dribbles from the bowl vent and kills the engine with a rich mixture. The newest cars with carburetors will be fitted with a special anti-

Some refiners have also tried to ease the octane problem by adding alcohol to gasoline. Alcohol works as an octane improver. An 87-octane unleaded gasoline with 10 percent ethanol (grain alcohol) added will gain about three octane numbers and become 90-octane unleaded premium. This practice began more than a decade ago during the oil crisis, because adding alcohol not only helped raise octane numbers but helped stretch scarce petroleum reserves. Some marketers add up to 10 percent ethanol, producing gasohol. To encourage this trend, many states and the federal government have enacted tax laws giving gasohol special tax breaks.

Other marketers add methanol—so-called wood alcohol, actually made today mostly from natural gas. It also raises octane and burns well in an automobile engine. The problem: "When you add ten percent ethanol to gasoline," says Clark, "its vapor pressure goes up one-half to one-and-a-half pounds." Methanol can cause a similar problem: R. H. Thring of the Southwest Research Institute reported in a Society of Automotive Engineers paper that adding even just two percent methanol to gasoline can raise its vapor pressure by more than three pounds—enough to get a lot of cars into trouble.

So, because of the quality of crude oil, blending problems, removal of lead, addition of light elements for octane improvement, and use of alcohols, vapor pressure has been creeping upward since the early '70s. How much is it actually up? Twice a year, in January and July, the Motor Vehicle Manufacturers Assn. takes about 450 gas samples from several dozen cities across the country. As the accompanying graph shows, pressure has gone from nine to above 10 in the summer, from 12 to above 13 in winter.

These levels, oil companies are quick to point out, are within industry standards, set by the American Society for Testing and Materials, a widely respected standards-setting group including representatives of both oil and auto companies. ASTM standards allow volatilities up to 15 in winter and 11.5 in summer. Thus if all gasoline were at average levels, the auto industry could probably live with it.

However, some experts claim that many blends now sold are substantially higher. Says Clark: "One night last winter I stopped at the six or seven gas stations between here and my house and got gas samples. When I got home I ran vapor-pressure tests on my kitchen counter. I got numbers in the sixteen-to-seventeen-pound area, where it should have been fifteen. The next day I took them down to the lab and confirmed those results. That's not a national scientific survey. But if I got more samples, particularly in winter, I'd bet that most would be outside of the standard." Of course, the other side of the coin is that if some gasoline is above average volatility—a point few deny—then other gasoline must be below.

But the problem is even more complicated. Some auto experts say the numbers, while within standards, are too high, that they should be brought back down to the nine summer and 12 winter of several years ago. So why don't the oil companies and blenders simply blend gasoline to have lower vapor pressure? Because the resultant fuel would cost more.

Why don't auto companies make cars more tolerant of high-volatility fuels? In fact, they have been making cars less sensitive to rising volatility by making changes such as adding more-powerful fuel pumps. But some auto men claim this has backfired. "When the oil companies found out that the new cars were less sensitive," says Joe Colucci of General Motors Corp., "they pushed the volatility up." Marvin Jackson, an emissions-control engineer at GM, adds: "If we build cars in 1990 that solve the problem,

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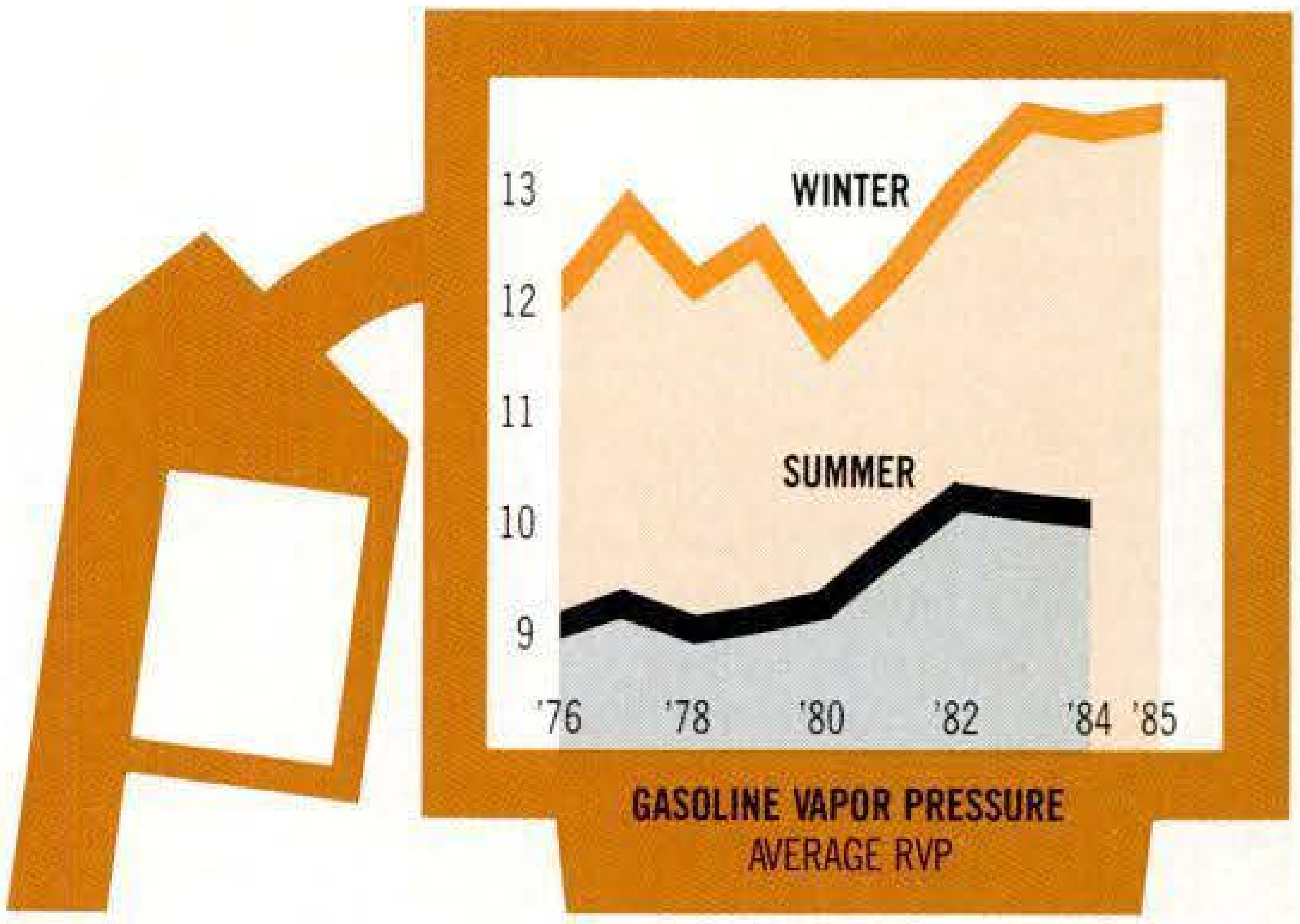
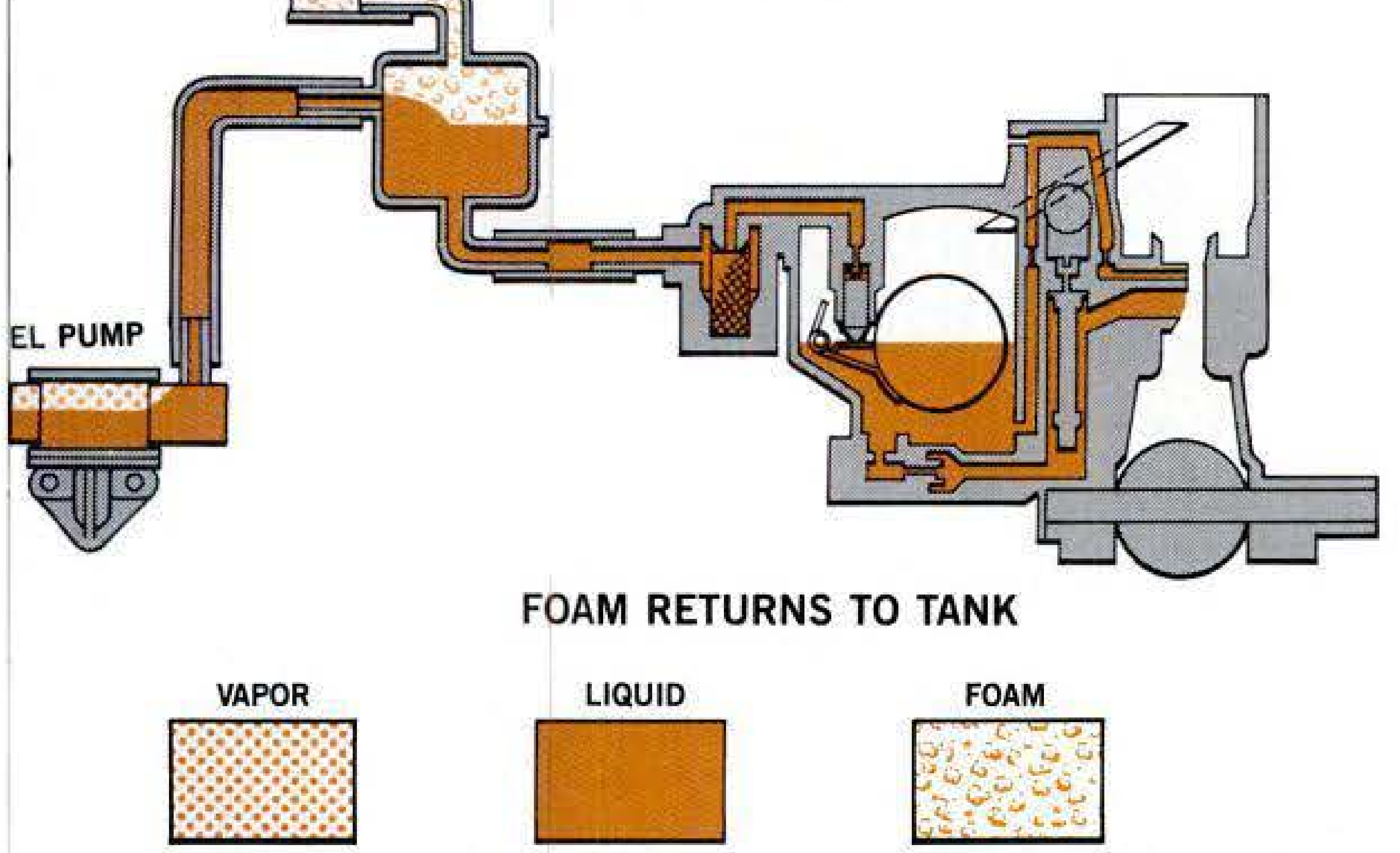


Gasoline volatility has been increasing for several years. Fuel specialists at the major automotive companies say it has affected both vehicle hydrocarbon emissions and warm-weather drivability. Further increases in gasoline volatility would mean more complicated emissions controls.

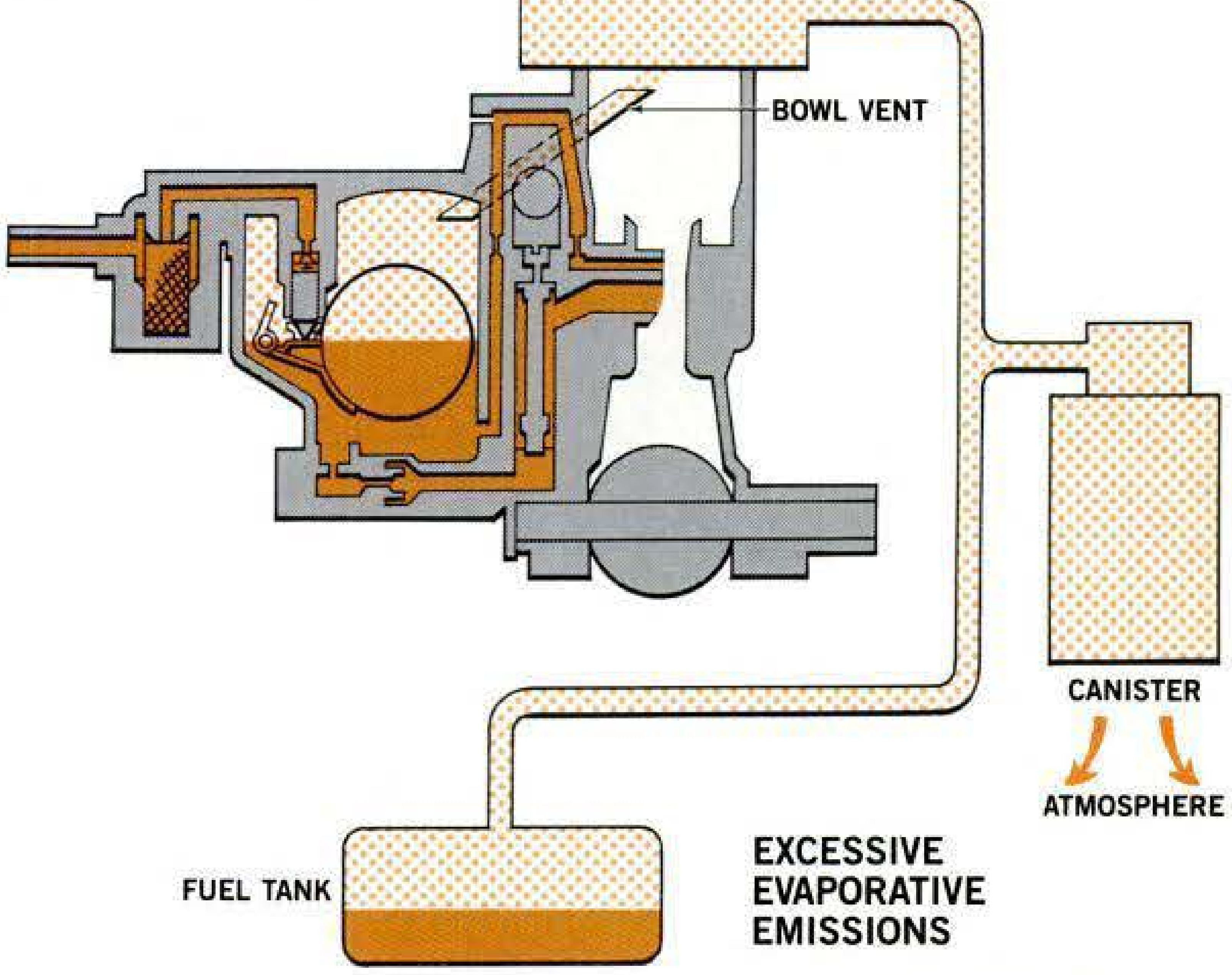
DRAWINGS BY RUSSELL VON SAUERS

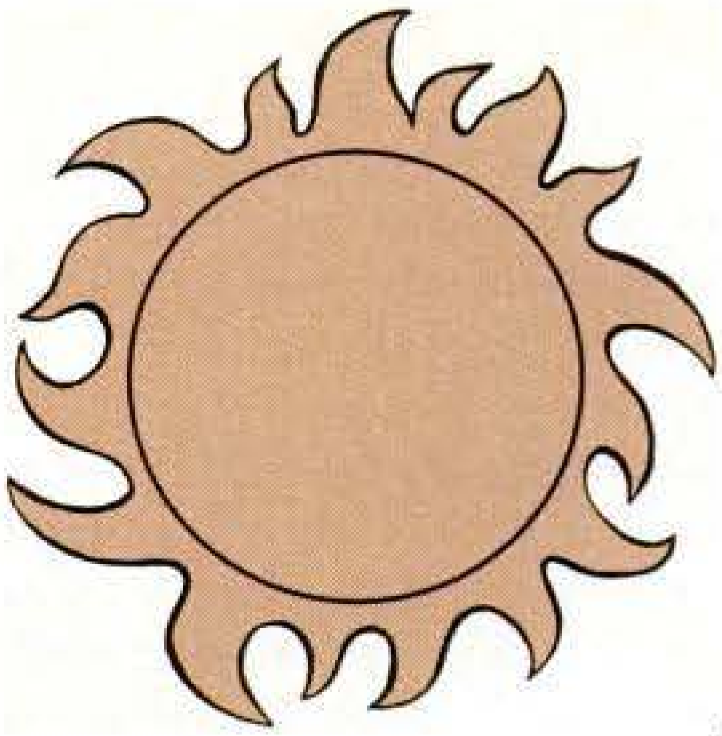
Fuel-foaming kit



foaming trap. The trap returns fuel foam to the gas tank. Higher-volatility fuels produce excessive amounts of vapor, which cannot be contained by the emissions system's charcoal canister. Vapor overload then vents to the atmosphere.

Canister overload





Superwindows

Advanced-technology windows emerged from research labs just a few years ago, but they're already sold by scores of window makers. Industry sources predict they'll grab 25 percent of the residential market in five years. One kind of high-tech window lets in more solar heat than do ordinary windows. But most keep in more room heat. And now there's a heat-saving glass that's tough enough to use as storm panels.

By V. ELAINE GILMORE

For window shoppers it is the best of times:

- You can now buy double-glazed windows that are more efficient than traditional *triple*-glazed units.
- You can buy superior triple-pane—or even quad-pane—windows that weigh no more than doubles.
- You can add new-technology storm windows to single-glazed heat-leakers and approach the performance of *triple*-glazed windows.
- You can buy high-efficiency windows for hot-climate houses.

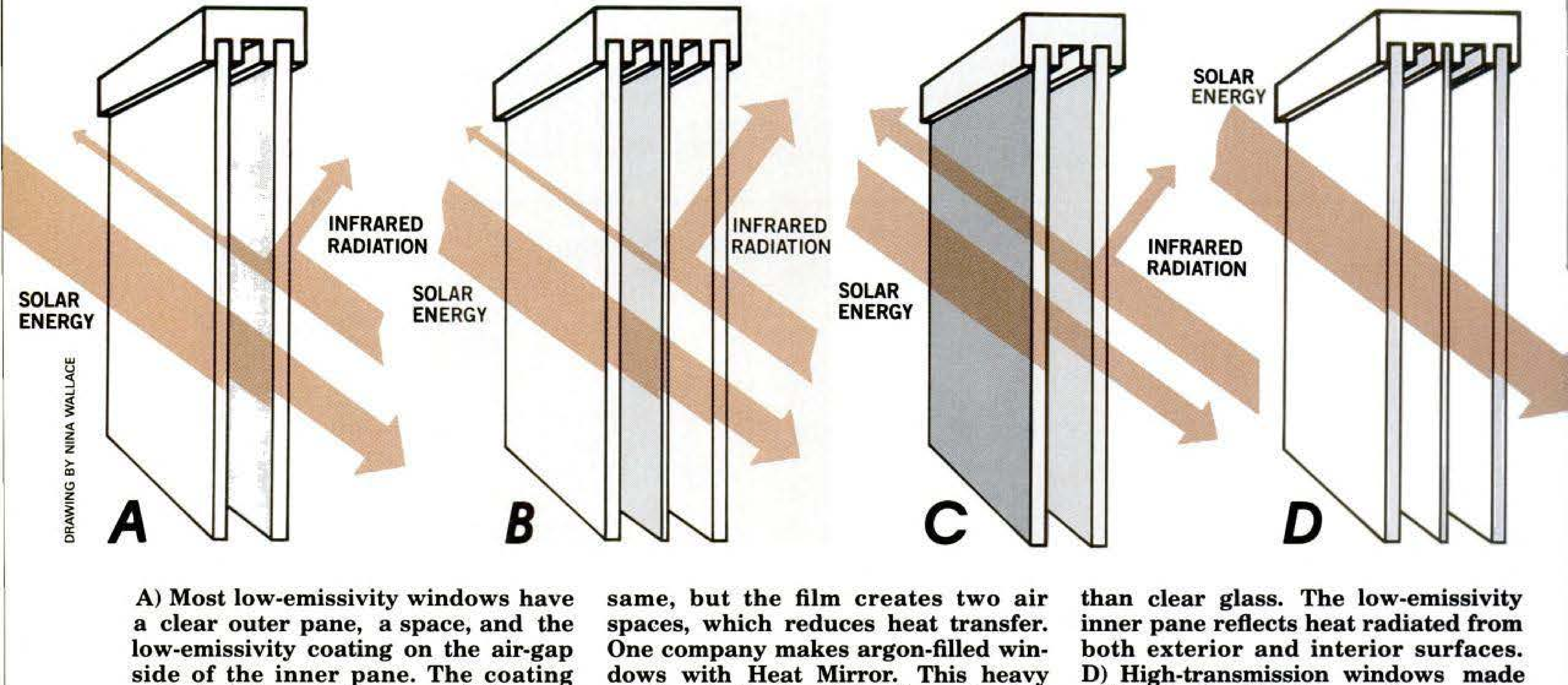
But when you go window shopping, you may decide it is the worst of times. The choices are broad and the claims confusing. These superwindows all owe their superior performance to specially coated glazings, but some are glass and some are plastic film. One film, a high-transmission glazing, transmits more solar energy than does glass. The other film and all of the glasses are low-emissivity glazings: Their coatings reflect heat. Low-emissivity glass comes in two varieties—and one is a better thermal performer than the other.

One thing the superwindows do have in common: They all are expensive. Nevertheless, their popularity is mushrooming, especially the low-emissivity types. "These coated glazings will eventually be the norm, not the exception," predicts Stephen Selkowitz, head of Lawrence Berkeley Laboratory's windows and daylighting research group. Here's what you should know before you window shop.

Low-emissivity windows

Sit near a window on a cold night, and you may feel chilly, even if the room is warm. One reason: Your body

[*Continued on page 114*]



DRAWING BY NINA WALLACE

A) Most low-emissivity windows have a clear outer pane, a space, and the low-emissivity coating on the air-gap side of the inner pane. The coating reflects infrared energy and thus reduces heat loss (and heat gain in summer). These windows transmit most of the solar energy. B) Low-emissivity windows made with Southwall's Heat Mirror, a coated polyester film, work the same, but the film creates two air spaces, which reduces heat transfer. One company makes argon-filled windows with Heat Mirror. This heavy gas is a better insulator than air. Another manufacturer makes argon-filled windows using Interpane's coated glass. C) Low-emissivity windows for hot climates have a tinted outer pane, which transmits less solar energy than clear glass. The low-emissivity inner pane reflects heat radiated from both exterior and interior surfaces. D) High-transmission windows made with 3M's SunGain transmit more solar energy than do standard glass windows. The film, like Heat Mirror, creates triple- or even quad-glazed windows without added weight. The added air spaces reduce heat flow.

How typical superwindows compare

Manufacturer (or importer) of glazings	Special Glazings: Brand	Coating	Emissivity	Typical windows made with special glazings: Description of typical windows (outside to inside)	R-value (winter)	U-value (winter)	Shading coefficient	Direct solar energy transmitted (%)	Visible light transmitted (%)	UV transmitted (%)	Comments
AFG Industries Box 929 Kingsport TN 37662	Comfort-E glass	P	0.38	⅛-in. clear glass, ½-in. air space, ⅛-in. Comfort-E glass	2.5	0.40	0.85	65	77	24.5	Windows cost 10%–15% more than standard double glazed; storm panels available
Andersen Corp.[1] Bayport MN 55003	High-Performance glass	S	0.11	2.4-mm clear glass, 11 mm air space, 2.2-mm High-Performance glass	3.1	0.32	0.72	57	76	30.0	All windows have wood frames; no horizontal sliders or custom windows available; cost: 9–11% more than standard Andersen double windows (3-by-4-ft. casement window: $190-$235)
	High-Performance Sun glass	S	0.07	3-mm High-Performance Sun, 10.5-mm air space, 2.2-mm clear glass	3.1	0.32	0.38	28	44	12.0	Low-emissivity coating is on tinted outside pane (facing air space); use where reduced solar gain is desired; cost: same as above
Ford Motor Co. Glass Div. 300 Renaissance Center Box 43343 Detroit MI 48243	Sunglas Heat Reflective (sputtered) glass	S	0.14	⅛-in. clear glass, ½-in. air space, ⅛-in. Sunglas S	3.1	0.32	0.81	58	76	26.0	Cost: 10–15% more than standard double windows
	Sunglas Heat Reflective (pyrolytic) glass	P	0.35	⅛-in. clear glass, ½-in. air space, ⅛-in. Sunglas P	2.5	0.40	0.82	66	73	56.0	Available in most sizes and configurations; cost: same as above; storm panels available
Guardian Industries 43043 W. Nine Mile Rd. Northville MI 48167	Low-E glass	S	0.10	⅛-in. clear glass, ½-in. air space, ⅛-in. Low E glass	3.1	0.32	0.74	56	77	<30.0	Available throughout U.S. and Canada
Interpane Coatings Box 26 Deerfield WI 53531	IPlus Neutral R glass	S	0.10	4-mm clear glass, ⅝-in. argon-filled space, 4-mm Interpane glass	4.5	0.22	0.71	62	75[2]	15.0	SNE Corp. (910 Cleveland Ave., Wausau WI 54401) uses Interpane glass in argon-filled windows sold under the Crestline and Vetter brands; a 4-by-4-ft. casement window has a list price of $425
				4-mm clear glass, 9⁄16-in. air space, 4-mm Interpane glass	3.4	0.29	0.71	62	75	15.0	Air-filled windows with Interpane are made by various U.S. and Canadian companies; glazing is said to match appearance of standard double glazing from outside
PPG Industries One PPG Place Pittsburgh PA 15272	Sungate 100 glass	S	0.10	⅛-in. clear glass, ½-in. air space, ⅛-in. Sungate 100 glass	3.2	0.31	0.79	58	74	49.0	Maximum glass size available: 84-by-144 in.
				⅛-in. bronze-tinted glass, ½-in. air space, ⅛-in. Sungate 100 glass	3.2	0.31	0.64	44	57	31.0	Use where reduced solar gain is desired
	Sungate 200 glass	P	0.31	⅛-in. glass, ½-in. air space, ⅛-in. Sungate 200	2.5	0.40	0.79	60	69	49.0	Available in more sizes than Sungate 100; storm panels available
				⅛-in. bronze-tinted glass, ½-in. air space, ⅛-in. Sungate 200	2.5	0.40	0.65	45	53	29.0	Use where reduced solar gain is desired
Sentinal Agencies Box 905 Miami FL 33137	Comfort Glass	P	0.15	3-mm clear glass, 12-mm air space, 3-mm Comfort glass	2.9	0.34	0.83	55	69	24.0	Sentinal imports Glaverbel low-emissivity glass from Belgium; storm windows available (limited distribution); glass has lowest emissivity of any pyrolytic coating listed—has slight bronze tint
Southwall Technologies 1029 Corporation Way Palo Alto CA 94303	Heat Mirror 44 film	S	0.05	¼-in. bronze-tinted glass, ½-in. air space, HM44 film, ½-in. air space, ¼-in. clear glass	4.8	0.21	0.25	12	22	<20.0	Recommended where solar control is required: skylights, sloped glazing, Sunbelt houses, commercial buildings
	Heat Mirror 66 film	S	0.08	⅛-in. clear glass, ½-in. air space, HM66 film, ½-in. air space, ⅛-in. clear glass	4.5	0.22	0.50	34	55	29.0	Costs the same as HM88 windows; recommended where solar shading in summer and insulation in winter are desirable; also for Sunbelt, especially for west-facing windows
	Heat Mirror 88 film	S	0.15	⅛-in. clear glass, ½-in. air space, HM88 film, ½-in. air space, ⅛-in. clear glass	4.3	0.23	0.71	54	71	43.0	Heat Mirror film generally adds $3–$5 per sq. ft. of glass area to cost of window; noise transmission reduced
				⅛-in. clear glass, ½-in. argon-filled space, HM88 film, ½-in. argon-filled space, ⅛-in. clear glass	5.1	0.20	0.71	54	71	43.0	Recommended for very cold climates (Alpen Inc., Denver CO, is the only U.S. maker)
3M Energy Control Products Div. Bldg. 225-48-08 St. Paul MN 55144	SunGain film	n.a.[3]	n.a.[3]	⅛-in. clear glass, ¼-in. air space, SunGain film, ¼-in. air space, ⅛-in. clear glass	2.8	0.36	0.85	66	79	6.0	SunGain film transmits solar energy better than clear glass; windows with SunGain list for $4–$12 more per sq. ft. than comparable double windows; recommended where both solar gain and insulation are important
				⅛-in. clear glass, ¼-in. air space, SunGain film, ¼-in. air space, SunGain film, ¼-in. air space, ⅛-in. clear glass	3.8	0.26	0.82	62	78	2.0	

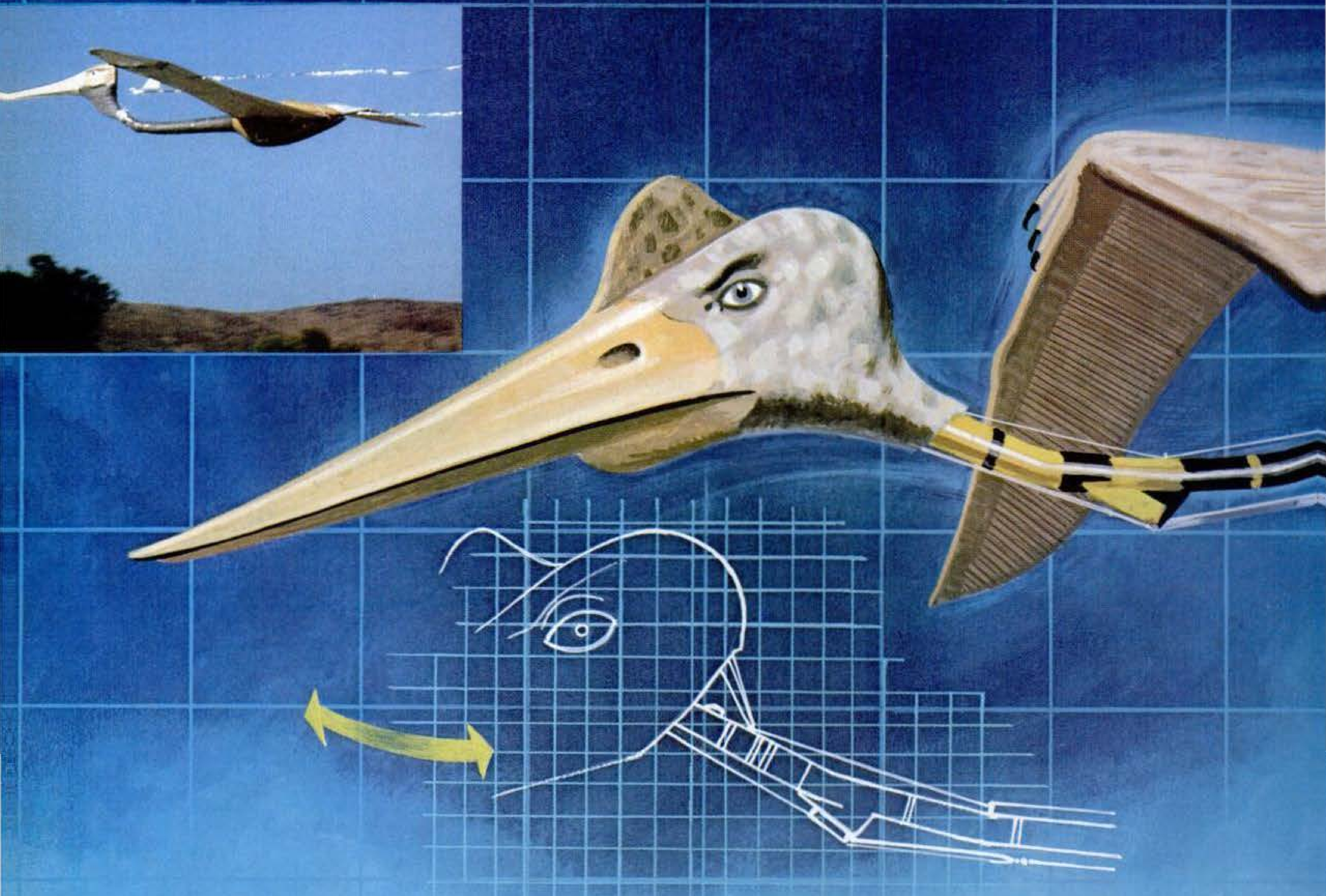
[1] Andersen Corp.'s low-emissivity glass is coated by Cardinal Glass Co., which supplies only Andersen; [2] Interpane makes another low-emissivity glass, called IPlus Neutral (its specifications are the same, except that it transmits only 70 percent of visible light); [3] not applicable

For comparison: conventional windows

Single-glazed	0.84	0.89	1.12	1.00	85	90	80.0
Double-glazed	0.84	2.00	0.50	0.89	73	82	67.0
Triple-glazed	0.84	2.80	0.35	0.82	64	75	57.0

The table reveals how the windows compare. The numbers were provided by the glazing manufacturers, as were the descriptions of typical windows made with their special glazings. Specifications consider the glass area only, without frame or sash effects. (You can write to the glazing manufacturers for lists of window makers that use their glazing, and ask window makers for the performance specifications of actual windows.) Here's what the table headings mean. **Coating:** Low-emissivity coatings are applied by the pyrolytic (P) or sputtered (S) method; **Emissivity:** a measure of how readily a surface absorbs and emits infrared energy (the lower the emissivity, the less infrared the glazing absorbs); **R-value:** a measure of resistance to heat flow (the reciprocal of the U-value); **U-value:** indicates how readily heat flows through a material in Btu/sq. ft./deg. F temperature difference (winter R- and U-values are generally calculated at 70° F inside temperature, 0° F outside, and a 15-mph wind; values given are for the window described; reducing the air gap would raise the U-value); **Shading coefficient:** a measure of heat gain through a window, it assumes that ⅛-in. clear glass has a shading coefficient of 1.0, and compares other glazings with this (the lower the shading coefficient, the less heat the window lets in); **Solar energy transmitted, Visible light transmitted, UV transmitted** are self-explanatory.

Look! Up in the sky! It's a bird, it's a plane
it's a pterodactyl



Paul MacCready, of Gossamer Albatross fame, has built a working replica of this prehistoric winged lizard. Because the top-heavy pterodactyl had an unstable design, MacCready's team worked closely with paleontologists to figure out how it flew. Using on-board computer controls, they've created the first wing-flapping machine to successfully fly.

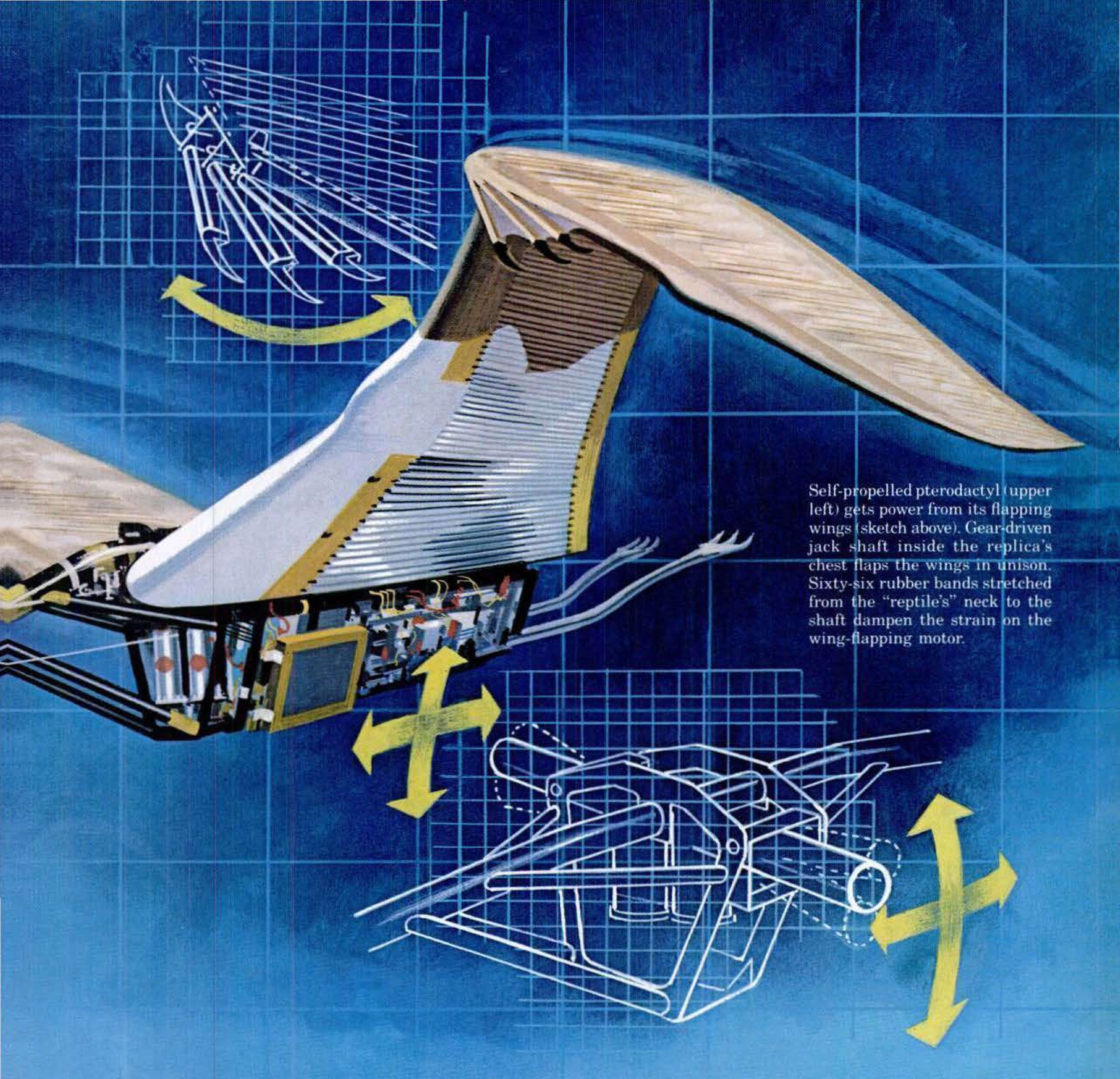
By JIM SCHEFTER
Illustration by Dean Ellis

Leathery wings stroke the warm spring air. With ponderous grace, their thrust lifts a fearsome white-eyed, sharp-beaked dragon higher and higher above the grassy mounds and long, narrow water hole. The beast's slender neck and head bob slightly with each beat. Fingerlike webbed claws on the leading edge of those giant wings flex, ready to act as air brakes.

Climbing in awkward circles, the prehistoric pterodactyl slowly takes on the grace of an airborne predator prowling the sky, studying the ground for its next meal. It circles the Washington Monument, perhaps soon to pounce on a distracted tourist.

Wait a minute! What is a 60-million-year-old relic from the late Mesozoic Period doing here, above Washington, D.C., in the spring of 1986? What could bring a flying reptile with an 18-foot wingspan to soar over the National Mall?

The answer is not what, but who: Paul MacCready, Ph.D., the lightweight-flying-machine genius. His human- and solar-powered aircraft burst through the frontiers of flight in the late 1970s and early '80s [PS, Oct. '77, Jan. '78, Dec. '78, June '81].



Self-propelled pterodactyl (upper left) gets power from its flapping wings (sketch above). Gear-driven jack shaft inside the replica's chest flaps the wings in unison. Sixty-six rubber bands stretched from the "reptile's" neck to the shaft dampen the strain on the wing-flapping motor.

Now MacCready's latest project, a half-size replica of *Quetzalcoatlus northropi*—a winged dragon vaguely related to dinosaurs—will fly under its own flapping power in late spring. The event will coincide with the premiere of *On the Wing,* a film about biological and human flight being produced by the Smithsonian Institution's Air and Space Museum. MacCready's creation will appear in the film.

Mother Nature took millions of years to create the pterodactyl, one of a family of pterosaurs ranging from bird-size to sun-blocking monsters. MacCready and his AeroVironment, Inc., team, expect to do the job in barely 12 months.

The $500,000 project is funded by the Smithsonian and Johnson Wax. Their purpose: to make the film realistic. MacCready's is simpler: to build the first large-scale machine that flies *successfully* by flapping its wings.

"Very little is known about how natural fliers combine their sensing devices, brains, and muscles to fly effectively," MacCready says. "The challenge is especially difficult with the pterodactyl; it doesn't even have a tail to help with stability and control."

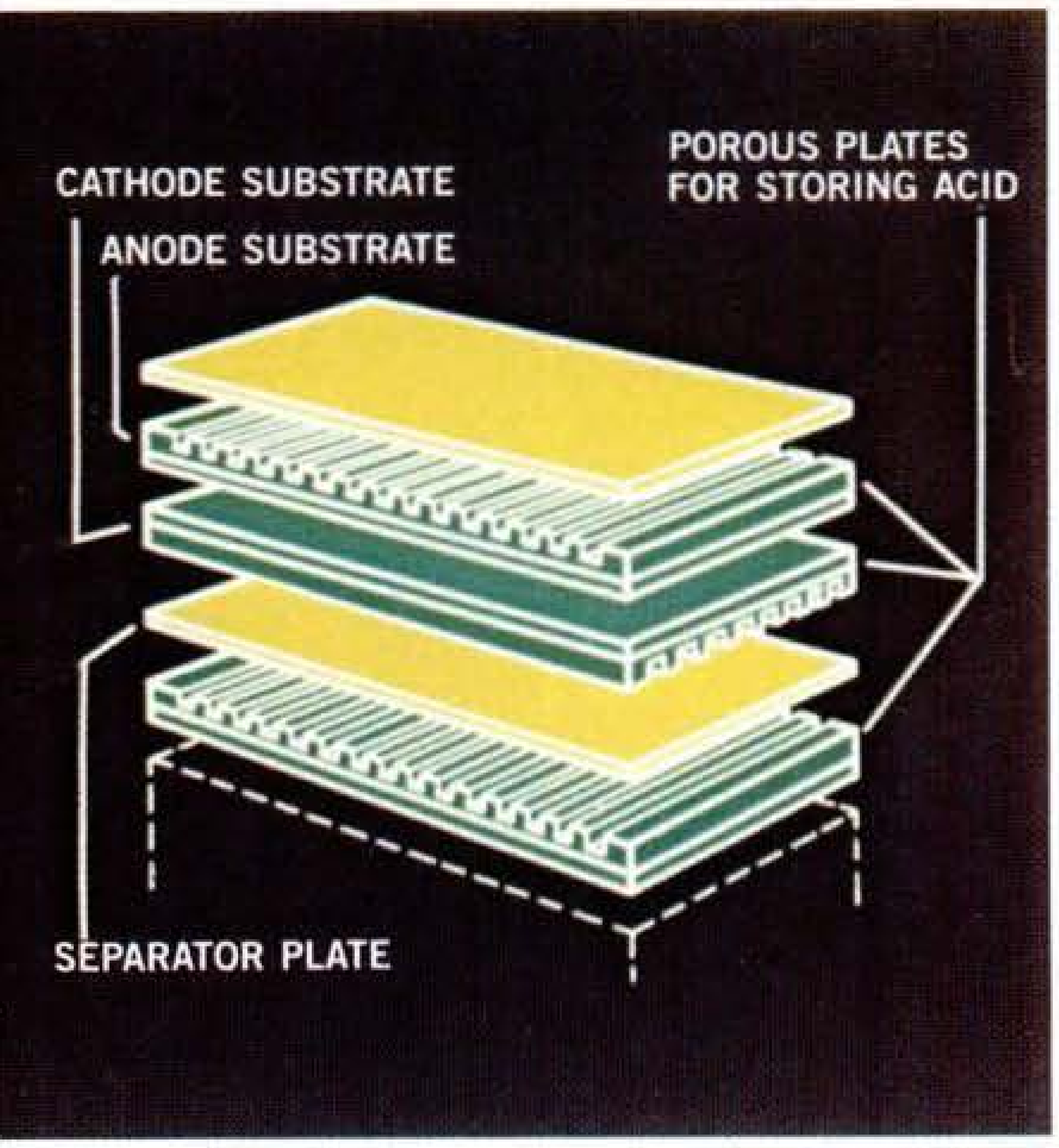
The pterodactyl's bones lay locked in an eons-old rock formation in Texas until paleontology graduate student Douglas Lawson found them in 1972. With University of Texas Prof. Wann Langston, he pieced together the dragon's form and called it *Quetzalcoatlus northropi*. Its 36-foot wingspan seemed to give it excellent lift. But by all aeronautical theories, the 140-pound creature simply shouldn't fly. Its long neck and beaked head should flip it backward if it tried. The only solution to that puzzle, aerodynamicists concluded, was that the pterodactyl shifted and wobbled its head in flight, using it as both a rudder and stabilizer.

"We have learned a great deal about how these giant creatures, which ruled the skies sixty-five million years ago, were able to fly," MacCready says. "The challenge to replicate natural flight has required innovations in aerodynamics, structures, and control technology."

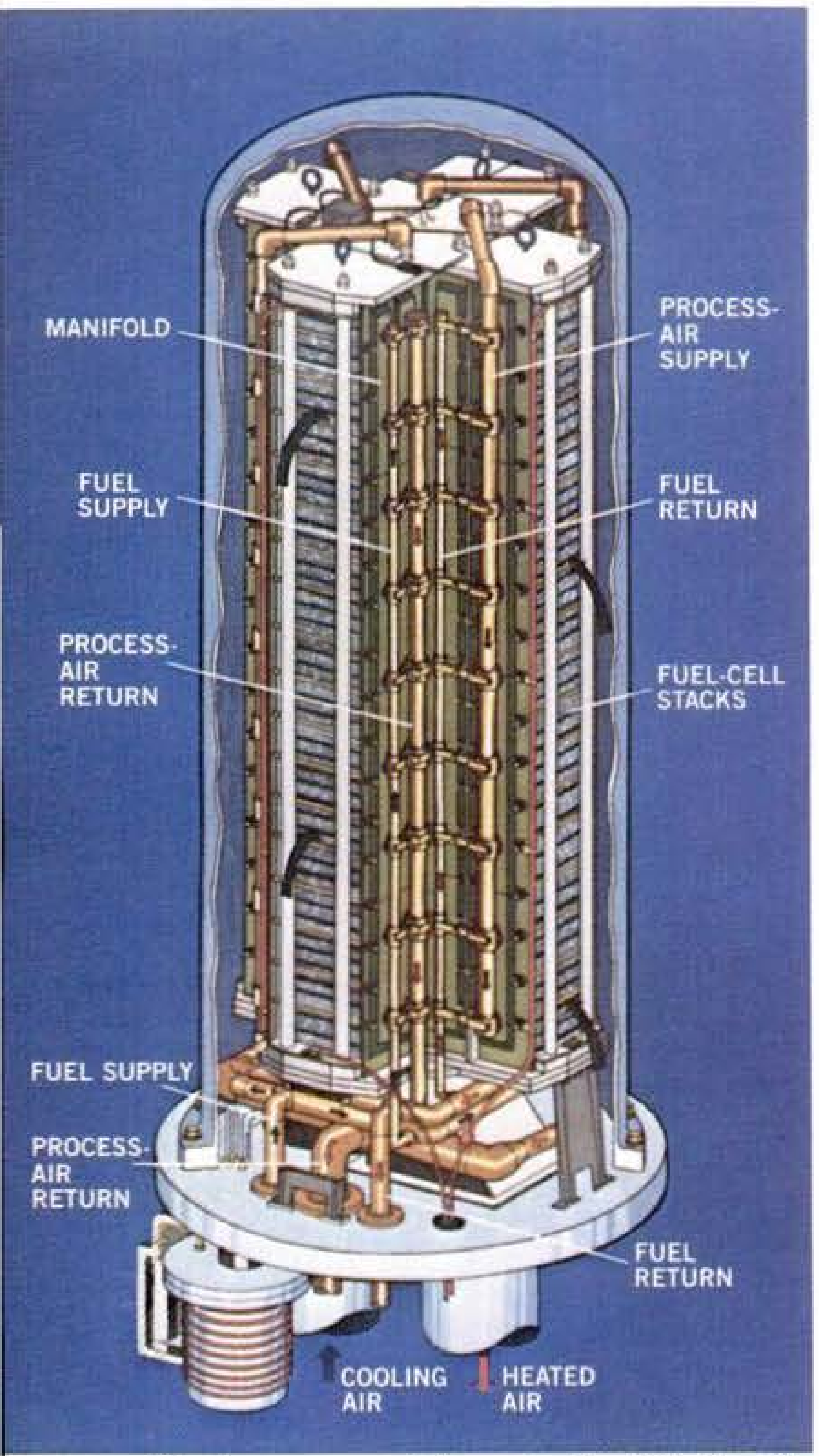
[*Continued on page 124*]

FUEL CELLS

—after 20 years of


CATHODE SUBSTRATE
ANODE SUBSTRATE
POROUS PLATES FOR STORING ACID
SEPARATOR PLATE

A fuel cell consists of a phosphoric-acid electrolyte in a porous material sandwiched between a cathode and anode. Fuel cells operate similarly to storage batteries used in flashlights, except the chemicals used are outside the cell.


MANIFOLD
PROCESS-AIR SUPPLY
FUEL SUPPLY
FUEL RETURN
PROCESS-AIR RETURN
FUEL-CELL STACKS
FUEL SUPPLY
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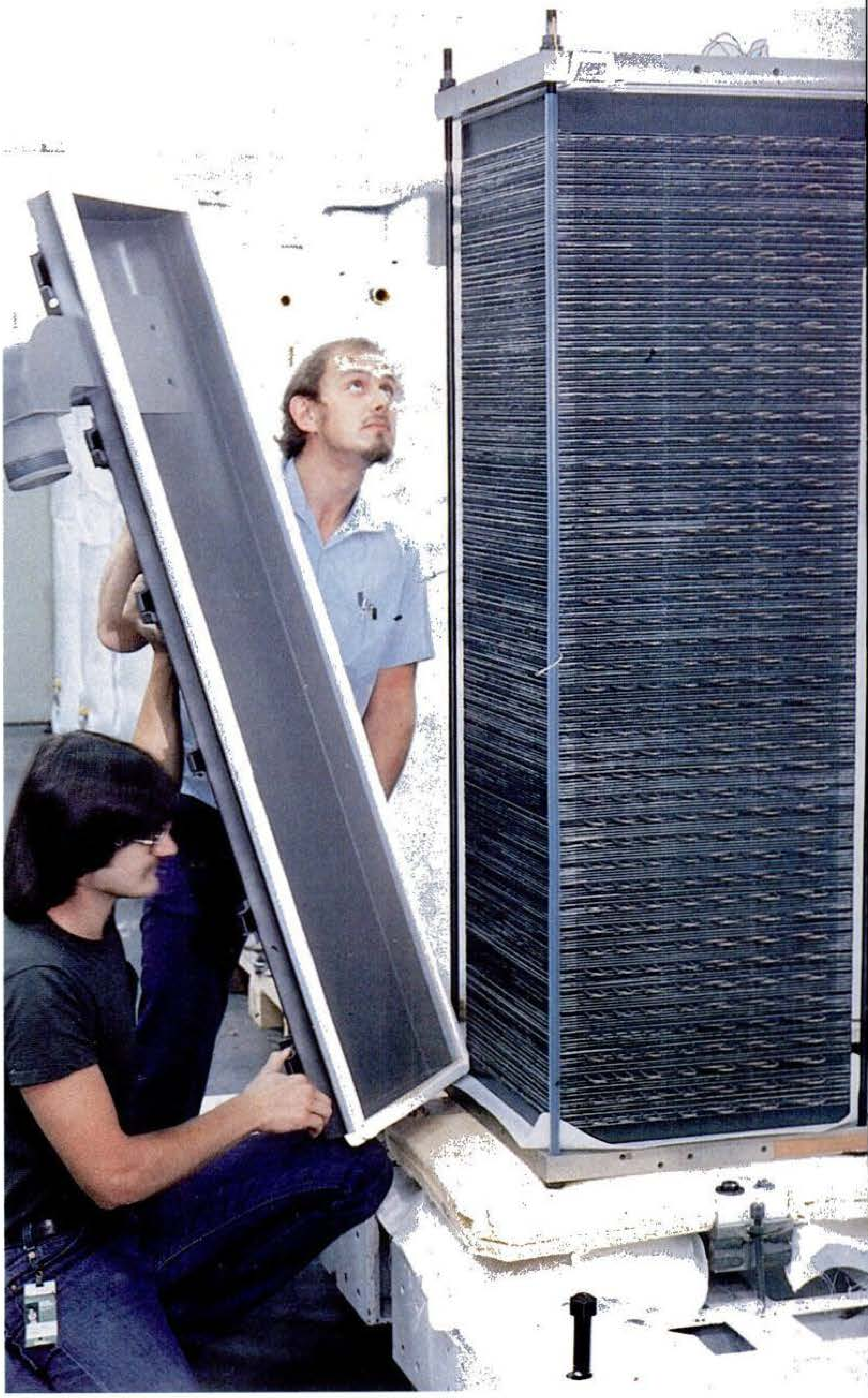
FUEL RETURN
COOLING AIR
HEATED AIR



Workers assemble a stack of fuel cells (right) for a 40-kW power plant built by IFC. Stacking numerous cells creates the high voltage needed for utility applications. A 375-kW fuel-cell module designed by Westinghouse (above) is 11 ft. high and 4.5 ft. in diameter, and weighs about three tons.

disappointments, they're coming on-line

No pollution, high efficiency, no moving parts, heat and water byproducts: Fuel cells that convert hydrocarbon fuel to electricity without burning it sound like an ideal source of power. Now, after long delays in development programs, industries and utilities are manufacturing and installing these power plants, first developed for spacecraft.

By JOHN FREE

INDUSTRY HILLS, CALIF.

A whir of fans and pumps fills the air near the nation's first methane-powered fuel cell. The device, somewhat larger than a Volkswagen van, delivers electricity, heat, and hot water to a hilltop Sheraton hotel in this Los Angeles suburb. From my hotel window nearby I notice the luxury resort's attractive landscaping. How can decaying garbage, which I've learned serves as a methane source, coexist here?

Early next morning, John Leeper, Southern California Edison project manager for fuel cells, solves the mystery. He waves toward a bumpy expanse of manicured grass and trees behind the fuel cell: "These two eighteen-hole golf courses," he says, "are built on a clay cap that seals off the ground over the garbage." Most landfill gas is burned at the hotel. The fuel cell, I learn, taps only a small part of the methane.

"We've been interested in fuel cells for a long time," says the young mechanical engineer. "This plant gives us the opportunity to get some operating experience."

Edison's Industry Hills plant is just one of several dozen on-site 40-kilowatt (kW) fuel cells, most of which operate with natural gas, now under test in this country and abroad. Much larger demonstration systems—one megawatt (MW) or more—for electrical utilities are either running, slated to start soon, or under development. The fuel-cell industry, after some two decades of erratic starts and stops, now seems to be moving rapidly toward commercial introduction of these power plants.

The devices, invented 147 years ago, helped power manned space flights starting in the 1960s. In 1971 I saw one of the first down-to-earth cells: a furnace-size 12-kW device powering an all-gas demonstration home. Cell development benefited from the push for alternative energy sources in the mid-1970s. But early demonstration fuel cells, although scaled up to a 1-MW pilot plant in 1977, never became commercial products.

Now, finally, electrical utilities, the federal government, the gas industry, and manufacturer International Fuel Cells (IFC, South Windsor, Conn.) are supporting field tests of the newest 40-kW on-site cells. Their goal: scaled-up 200-kW power plants for apartment buildings, stores, light industry, and similar sites.

Most of the 1-to-4.5-MW utility-size plants are in Japan. IFC, a joint venture of Toshiba and United Technologies, plans to offer giant 11-MW plants within two years. But Southern California Edison recently withdrew from a plan to install a 7.5-MW fuel-cell system designed by Westinghouse (Pittsburgh, Pa.).

Such hesitancy isn't unusual. Says Leeper: "Manufacturers are reluctant to build a plant without orders, and there's a similar reluctance of utilities to buy cells without seeing them first."

Migrating acid

A recent fuel-cell project became both a disappointment and a lesson for developers. The project, a 4.5-MW demonstration plant built by United Technologies for New York's Consolidated Edison, is now rusting, unused, in lower Manhattan. But in 1978, when the project got underway, the plant seemed to be an ideal utility demonstration:

- Modular design and fast construc-

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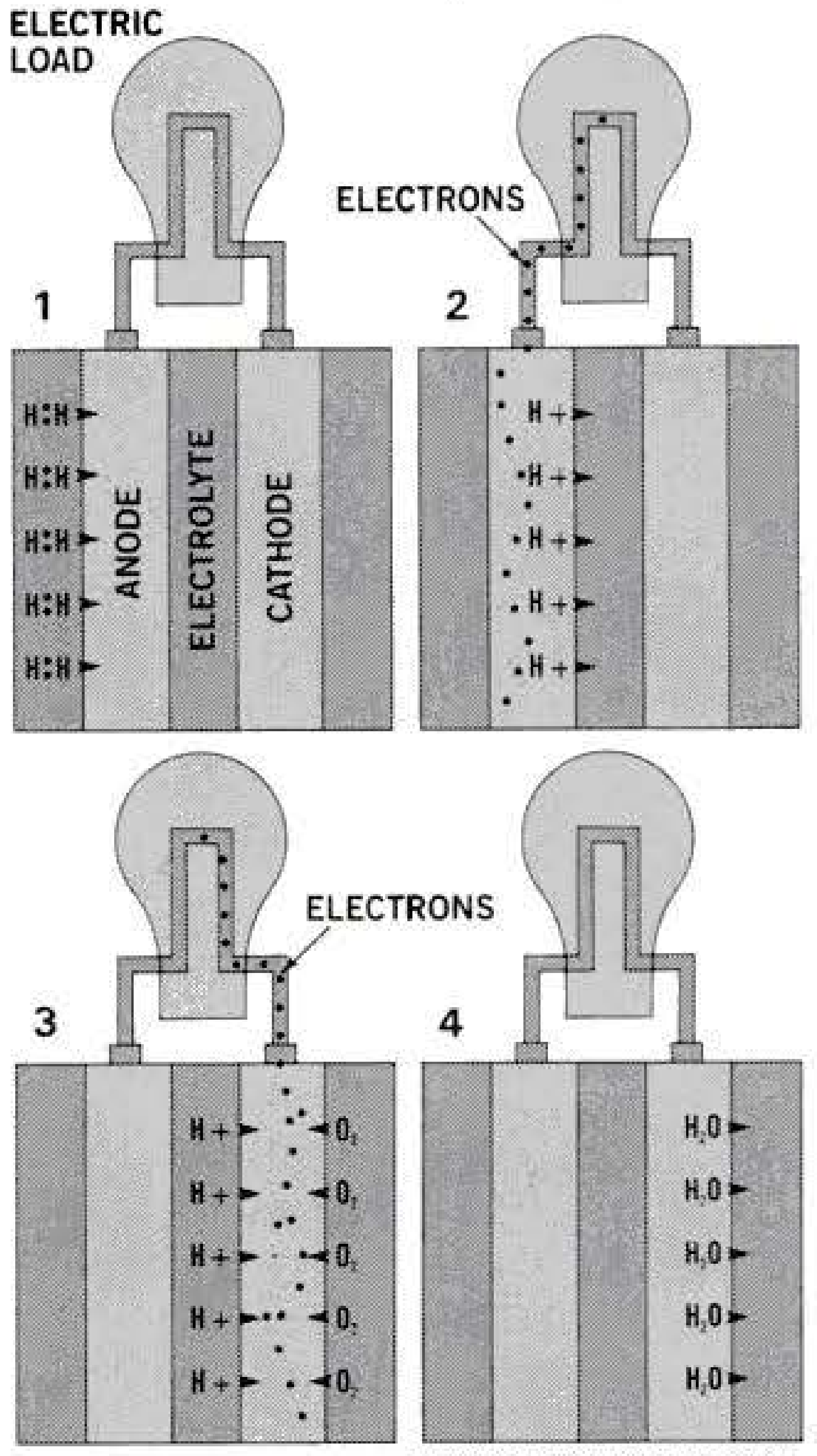
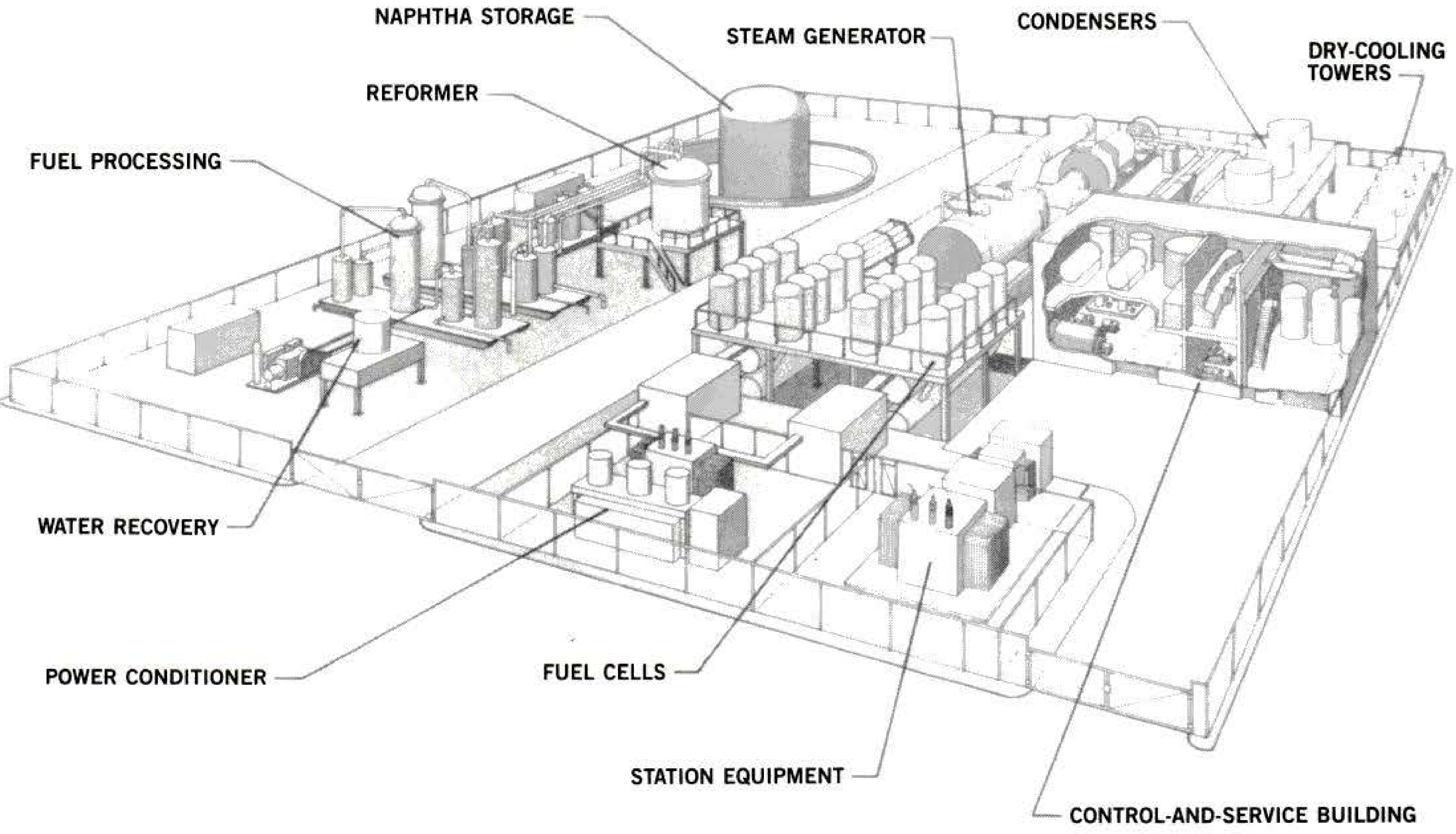
How fuel cells operate



DRAWING BY ELIOT BERGMAN

Hydrogen fuel gas flowing over a porous anode saturated with an electrolyte (1) is oxidized and loses its electrons. The anode develops a negative charge (2). At the same time, oxygen in air passed over the cathode attracts electrons, creating a positive charge on this electrode (3). Excess electrons from the anode, attracted to the cathode, flow through an external load (the bulb) as direct current. Positively charged ions, produced as hydrogen is oxidized at the anode, migrate through the electrolyte to the cathode. There they combine with oxygen ions to form water (4). This reaction creates heat, so water produced is steam. Higher pressures and temperatures in newer systems enhance this entire energy-producing process.

For peak utility loads: modular fuel-cell power plants



Preliminary design for a 7.5-MW fuel-cell plant by Westinghouse includes 20 cell modules, each with 375 kW. Power-conditioning gear converts the DC output of the cells into AC. Modules will be air cooled, with recovered heat used to produce steam and drive a small turbine that helps operate the plant. The expandable system is slated for 1988.

tion for this type of plant permits added capacity as customers require more power.

- Clean, virtually noiseless operation simplifies urban siting, right where power is needed.
- High operating efficiency extracts more energy from costly natural gas or oil-distillate fuels (40-percent efficiency for electricity generation versus 30 percent from current small generators; 80 percent if heat produced is also used).

That sounded good to Con Edison and other sponsors. But local residents, alarmed about fuel storage and processing at the site, delayed construction and forced fire officials to conduct elaborate safety tests. One of the tests, pressuring cell-site pipes with water, led to leaks and damage in cold weather.

Finally, in 1984, engineers turned on the reformer, a heater that converts natural gas or liquid hydrocarbon fuels into hydrogen-rich gas. As steam vented from the reformer, hydrogen began flowing into two trailer-truck-size containers packed with cells. They switched the system on and watched the voltage gauges.

Nothing happened. The giant fuel cell wouldn't work—and still doesn't. The reason: During the several years of delays before the start-up attempt, acid sandwiched in a porous material between cell electrodes had migrated away from the plates. That made the plant's 9,000 cells useless because without the acid electrolyte, current couldn't flow.

Meanwhile, in Japan, a similar 4.5-MW plant designed by United Technologies had been delivering power into Tokyo's power grid for a year. The Japanese benefited from newly designed cells, and located their plant at a noncontroversial site.

Filtered methane

Most fuel-cell test plants operate on natural gas or processed naphtha, but Leeper says California can also benefit from using alternative fuels. "Landfills, digestor facilities, industrial byproduct gases—they're all sources that are often either flared or vented," Leeper says.

His company is studying how much this gas must be cleaned up before use. Leeper points to a series of cylinders clustered around the Industry Hills cells that filter landfill methane gas. Two fat tanks towering over the cells, he explains, filter out chlorinated hydrocarbon compounds with activated carbon. A series of taller but narrower tanks remove carbon dioxide with a membrane-separation process. "Our hope is that you won't need anywhere near the purity of natural gas," says Leeper.

Raising temperatures

Advanced fuel cells under development promise better performance. One type uses a molten carbonate salt instead of an acid electrolyte, and delivers 55-percent electrical efficiency. The temperature in these molten-salt cells averages 1,200 degrees F—four times higher than acid cells.

Because of these higher operating temperatures, the costly platinum catalysts used to speed chemical reactions in conventional cells aren't needed. Some molten-cell designs also use the higher internal tempertures to eliminate the external reformers that generate hydrogen. And steam produced may also spin turbines to generate additional electricity.

Still another type of system under development: solid-oxide cells. They operate at some 1,800 degrees F, approach 60-percent electrical efficiency, use a wide variety of fuels without need for a reformer, and are easier to design, claims George Wiener of Westinghouse. Says Wiener: "A product can be made available for commercial introduction as early as 1990."

Expert systems promise supersmart PCs

Expert-system software is a spinoff from artificial-intelligence research. The computer learns about a subject by quizzing human experts, then becomes the expert in that field. Ask a question, and the computer searches its knowledge base to offer advice. The programs have been used on large computers for some time, but now they're available for desk-top microcomputers. An expert at your fingertips? The experts aren't sure.

By WILLIAM J. HAWKINS
Drawing by Roy Doty

I have to face facts," said Aldo Cimino. "I'm sixty-three years old and ready for retirement."

Cimino is a rare individual. He's an expert at cooking soup—millions of gallons of it. And for 43 years, the Campbell Soup Co. has relied on him to make sure the brew was just right. Who could take over? The answer is a personal computer programmed with expert-system software.

Expert systems teach a computer to think, not just juggle numbers or data from one place to another as it does with conventional programming. An expert system accepts knowledge —human knowledge—processes it, draws conclusions, and arrives at an answer a human expert would give if asked the same question. "It's the closest we can get to cloning," says Randall Davis, associate professor at the Massachusetts Institute of Technology's Sloan School of Management.

These new programs are rooted in 30 years of work done in artificial intelligence. In the past, only room-sized main-frame computers or, more recently, expensive minicomputers could handle the programming needed to mimic an expert [PS, Sept. '82]. However, the speed and power of personal computers has increased enormously over a short period of time, and now expert-system programs are available for IBM PCs and other compatible computers. The programs are not cheap: You can pay as much as $10,000 for one, but most are well under $1,000.

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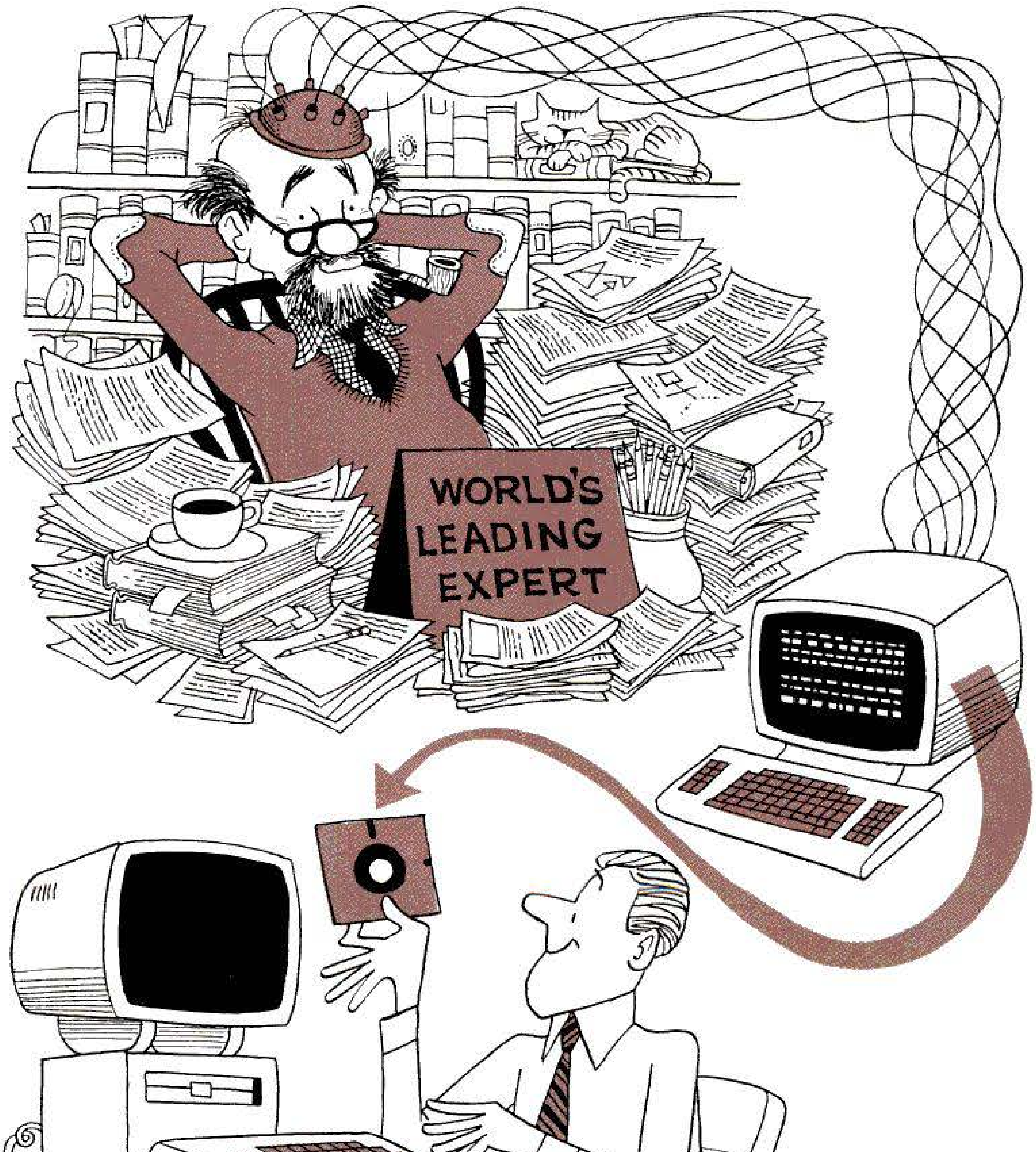


How do these programs work? How well? To find out, I talked to the experts on expert systems, program publishers, and users. I was surprised to learn that when you buy one of these off-the-shelf programs, it is incomplete: It isn't an expert in anything, and it is up to you to provide the knowledge. Despite many ease-of-use claims, entering knowledge is a laborious task often requiring months of work. And the results, claim the experts, can range from an expert advisor to a well-informed helper.

Shell game

"A complete expert system contains three main parts," explains Edward Feigenbaum of Stanford University. "It has a human-machine interface, an inference engine, and a knowledge base."

The human-machine interface lets the system communicate with the user. It accepts your questions, for instance, and it shows results in either textual or graphic form. An inference engine is the thinking brain behind an expert system. It is the part of the program that draws conclusions based on the facts stored in its knowledge base. What's a knowledge base? That's the part that the user—working with a human expert—must supply.

Because only the human interface and inference engine are contained in the personal-computer programs, the programs are called shells or tools. They are incomplete and become expert systems only when a knowledge base—the expertise on a particular subject—is added.

Knowledge is added to these systems in one of three ways: rules, frames, or logic. Rule-based systems use a series of if/then statements.

"Suppose I want to create an expert system to trouble-shoot my car," said Bruce Buchanan, professor of computer science at Stanford University. "In a rule-based system, one rule might be, *If the gas tank is empty, then get gas.*"

Frame-based systems use examples and become a network of associations. "With these," continued Buchanan, "I must explain what a gas tank is and how it works." And in a logic-based system each component must be specified as a mathematical formula. "System *knowns*, such as the gas tank, become constants," he said, "*unknowns* become variables, and the program becomes a theorem prover."

Of the three, rule-based expert systems are easiest to program. But ease of use is relative: All companies warn that a novice computer user will have trouble converting an expert's knowledge into rules that the computer can understand. For that reason, when Campbell Soup decided to use Texas Instruments' Personal Consultant expert-system shell, they also hired one of the company's expert-system programmers, formally called a knowledge engineer.

Is it soup yet?

"The first thing you do," says Michael Smith, knowledge engineer for Texas Instruments, "is learn all you can about the problems."

For Campbell Soup, the problems were spread around the world. Over 90 hydrostatic and rotary sterilizers are used in various factory sites to sterilize the ingredients that go into the company's canned soup. Each cooker is 72 feet tall and 18 feet at the base, and can hold from 55,000 to 68,000 cans of soup. Whenever there was a problem—from a bent can to an improper temperature—it meant a lengthy phone call, or a visit, by the company's trouble-shooter, Aldo Cimino. That job was to be replaced by the expert system.

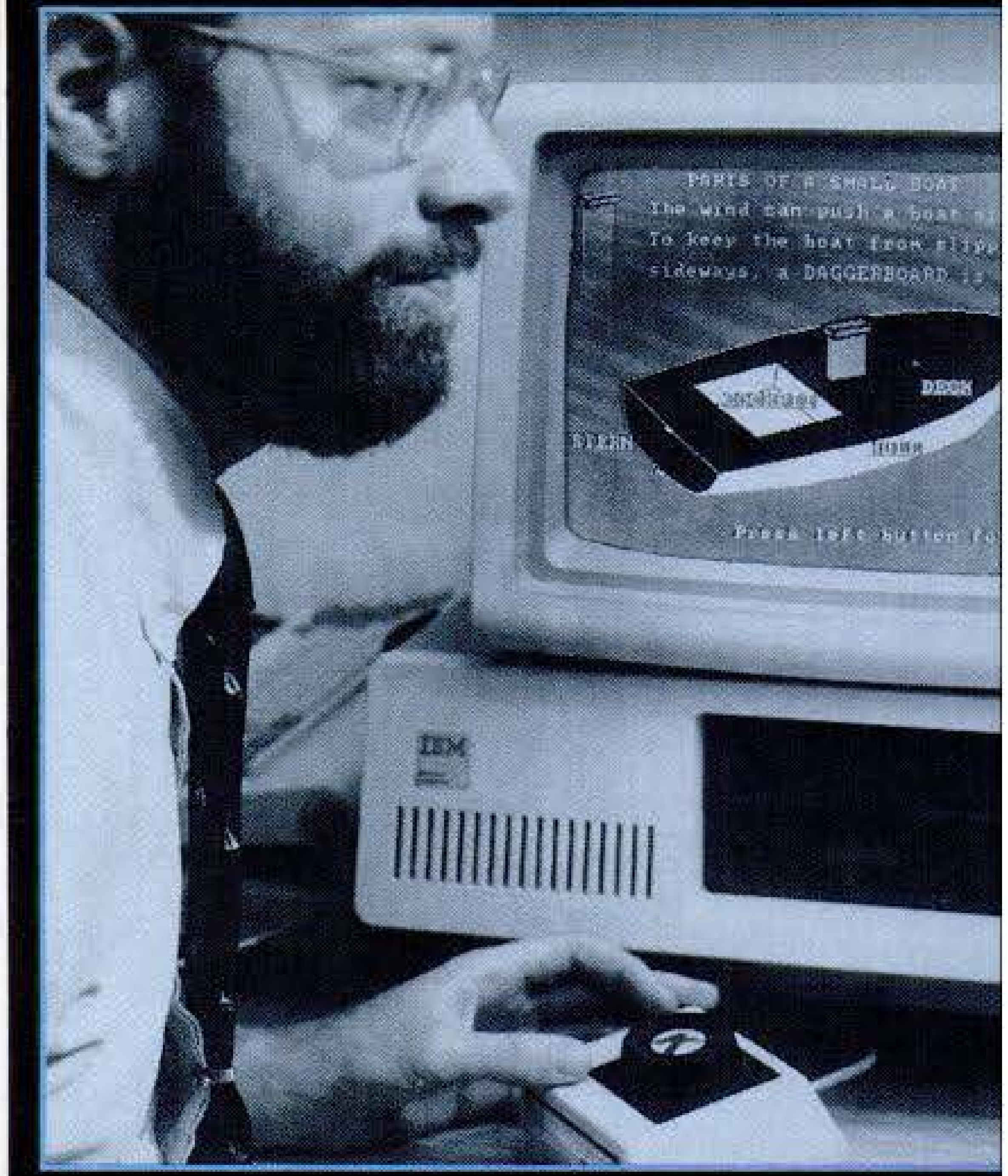
"When Smith and I got together for the first time," says Cimino, "I didn't know exactly what he wanted. I began by explaining how the sterilizer worked. He then began to understand what some of the problems were."

"The first session with Cimino lasted four days," says Smith. "He would explain operations to me, and I'd take notes." Smith then went to work, writing Cimino's information as rules for the expert system to use. "It took over a month to put together the first system," recalls Smith. "I then showed the hundred-and-ten-rule package to Cimino, and we tried it."

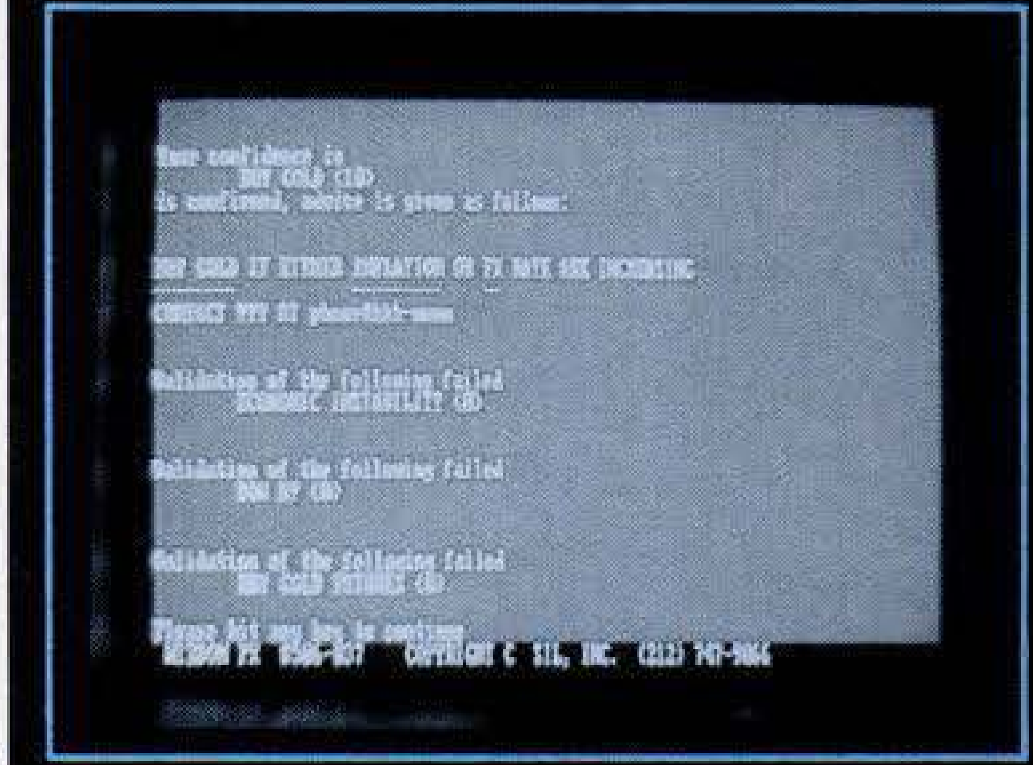
The trials went on for several months. Each time, Smith would change or add rules to the program to more accurately reflect Cimino's responses. The final system contains 151 rules.

"At first," says Cimino, "I didn't believe that what I knew would be beneficial to anybody. However after going through the whole system, I believe that ninety percent of my knowledge is in the program. It will give people unfamiliar with a cooker a general idea of where to look for a problem. For those knowledgeable in the field, it will save a large amount of time."

What about the other 10 percent? The experts are quick to point out that there is always room for human intervention. "If most of the decision-making responsibility is done by the machine, it is an expert," says MIT's Davis. But expert systems can be used as colleagues or assistants as well. "It depends on how much of the final work is done by the human, and how much is done by the machine."


PARTS OF A SMALL BOAT
The wind can push a boat
To keep the boat from slip
sideways, a DAGGERBOARD i
STERN
BOW
Press left button
IBM

Educational expert systems like RCA's prototype Skipper program can teach the basics on a variety of subjects.

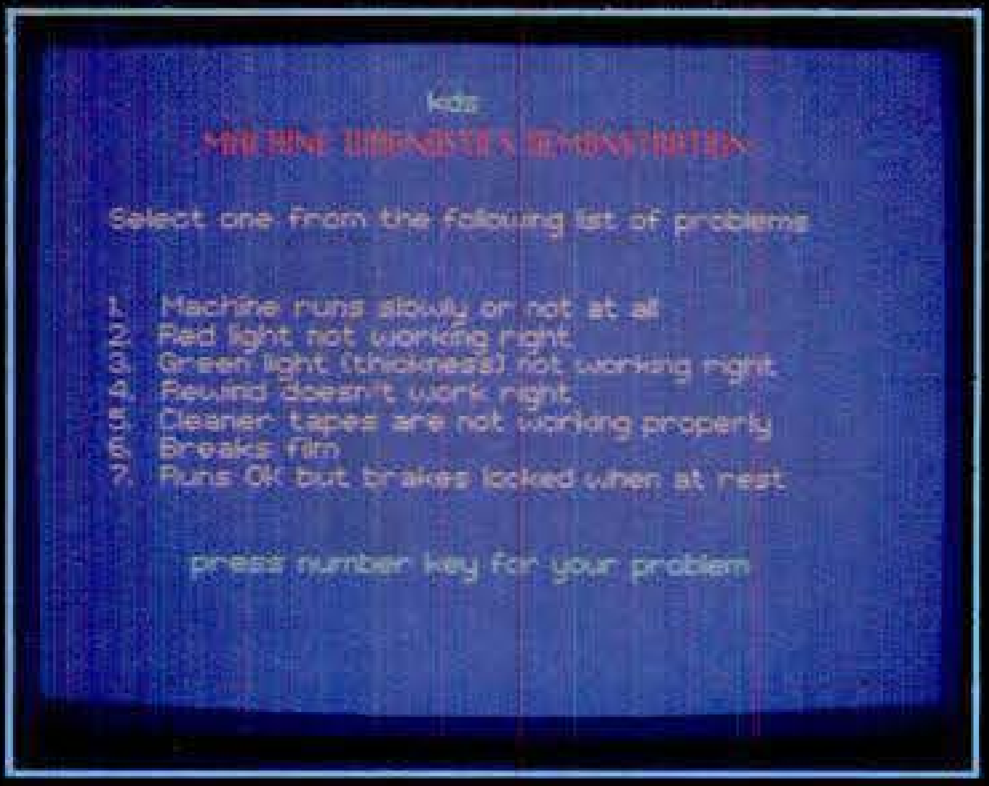


Example-based systems like Wizdom learn from past experience. Its conclusions—and reasoning—are shown.

Can anyone become an expert using one of these programs? To find out, I tried The KDS System to become a crackerjack electronics technician. The expert shell comes on one disk; the knowledge base, in this case one with rules for trouble-shooting a somewhat complicated film-inspection device, is on a second disk.

The program begins by asking general questions about the type of failure you're trying to trouble-shoot (see photos). I answered by selecting a numbered answer from a menu or by typing a "Y" or "N" for yes or no. I entered a "?" if I didn't know the answer. For every response I gave, the program showed me a new screen and the questions became more specific.

"It's going through its rules," Barbara Wallace, president of KDS and developer of the program, told me, "eliminating ones that don't apply to your answer and finding ones that do." This step-through process is called chaining. Expert systems use forward



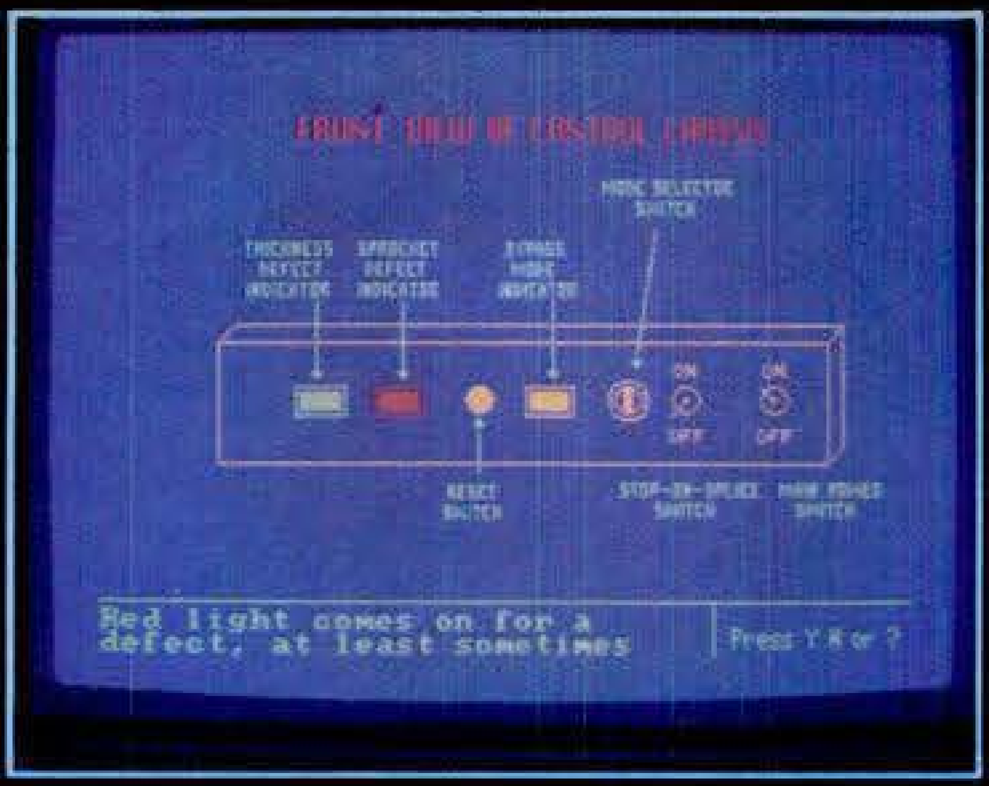
kds

MACHINE DIAGNOSTICS DEMONSTRATION

Select one from the following list of problems

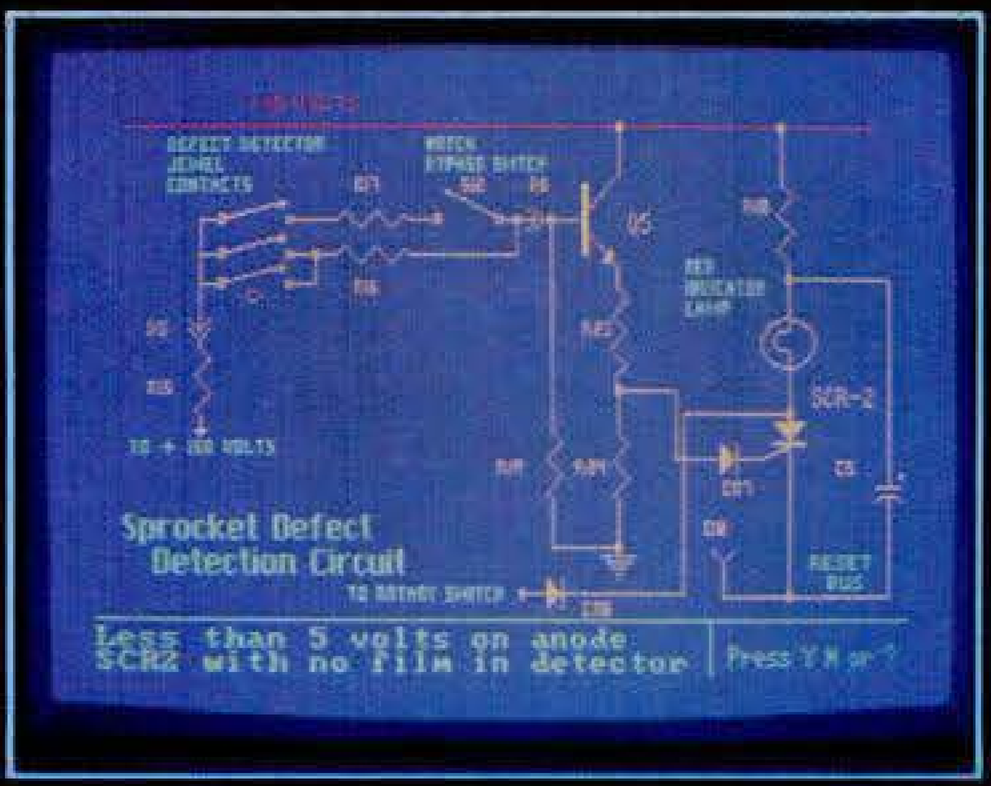
1. Machine runs slowly or not at all
2. Red light not working right
3. Green light (thickness) not working right
4. Rewind doesn't work right
5. Cleaner tapes are not working properly
6. Breaks film
7. Runs OK but brakes locked when at rest

press number key for your problem



Red light comes on for a defect, at least sometimes

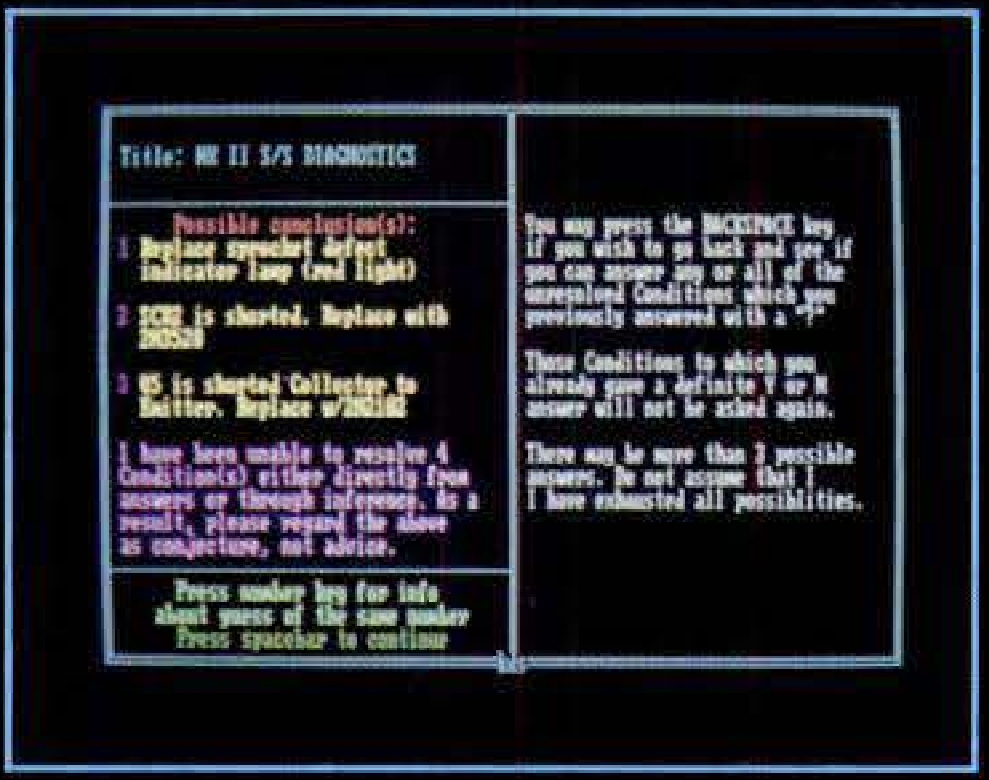
Press Y N or ?



DEFECT DETECTOR JEWEL CONTACTS
BYPASS SWITCH
Q5
RED INDICATOR LAMP
SCR-2
RESET BUS
Sprocket Defect Detection Circuit

Less than 5 volts on anode SCR2 with no film in detector

Press Y N or ?



Title: MK II S/S DIAGNOSTICS

Possible conclusion(s):

1 Replace sprocket defect indicator lamp (red light)

2 SCR2 is shorted. Replace with 2N5520

3 Q5 is shorted Collector to Emitter. Replace w/2N2102

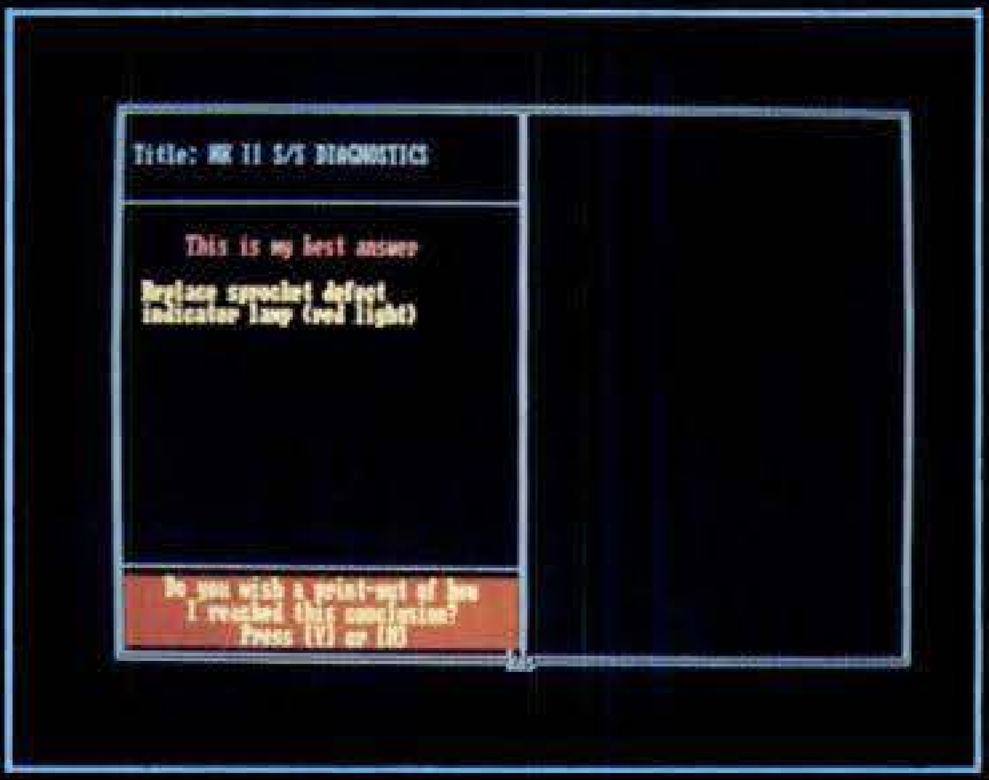
I have been unable to resolve 4 Condition(s) either directly from answers or through inference. As a result, please regard the above as conjecture, not advice.

Press number key for info about guess of the same number
Press spacebar to continue

You may press the BACKSPACE key if you wish to go back and see if you can answer any or all of the unresolved Conditions which you previously answered with a "?"

Those Conditions to which you already gave a definite Y or N answer will not be asked again.

There may be more than 3 possible answers. Do not assume that I I have exhausted all possibilities.



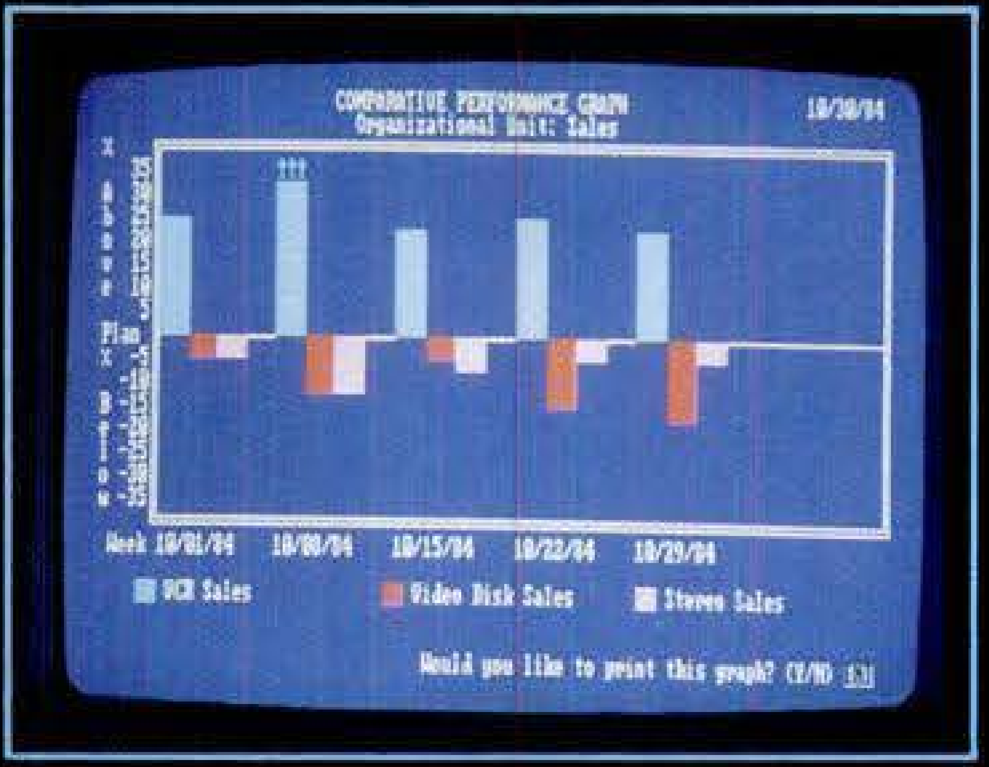
Title: MK II S/T DIAGNOSTICS

This is my best answer

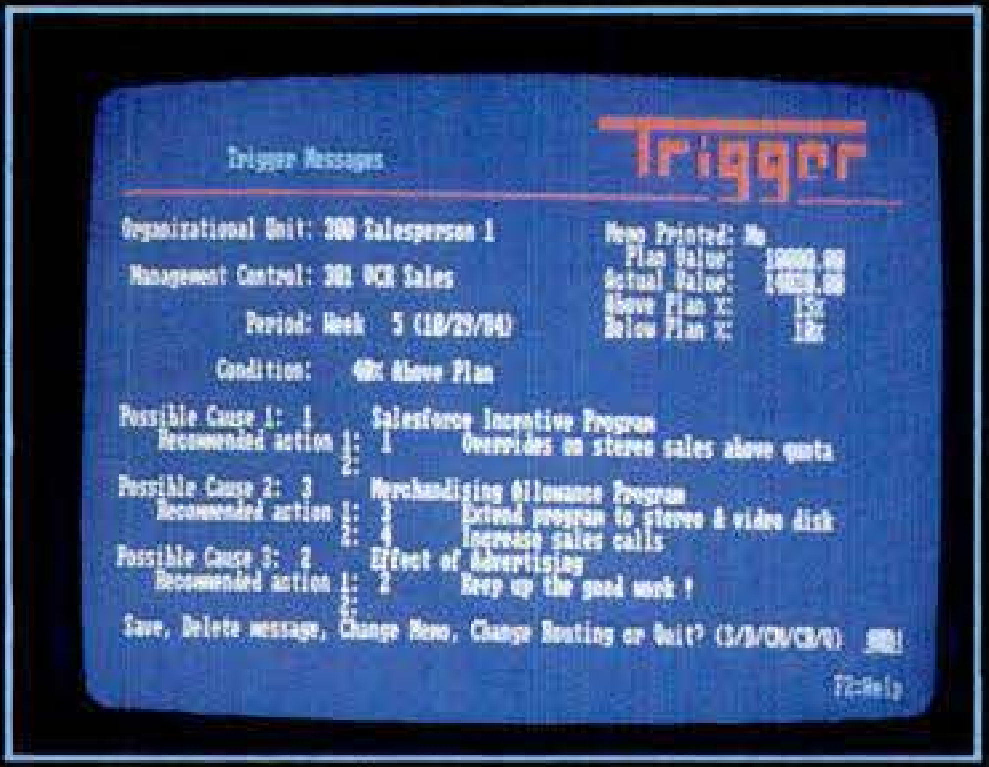
Replace sprocket defect indicator lamp (red light)

Do you wish a print-out of how I reached this conclusion?
Press (Y) or (N)

Trouble-shooting electronic gear is done in steps using the KDS expert system. The questions begin easy, and become harder as the system narrows down a cause (top three photos). Based on your answer, the system tries to determine the problem. Sometimes not enough information is available (far left photo); other times the solution is given (left).



Would you like to print this graph? (Y/N)



Trigger Messages

Trigger

Organizational Unit: 300 Salesperson 1

Management Control: 301 VCR Sales

Period: Week 5 (10/29/84)

Condition: 40% Above Plan

Memo Printed: No
Plan Value: 10000.00
Actual Value: 14020.00
Above Plan %: 15%
Below Plan %: 10%

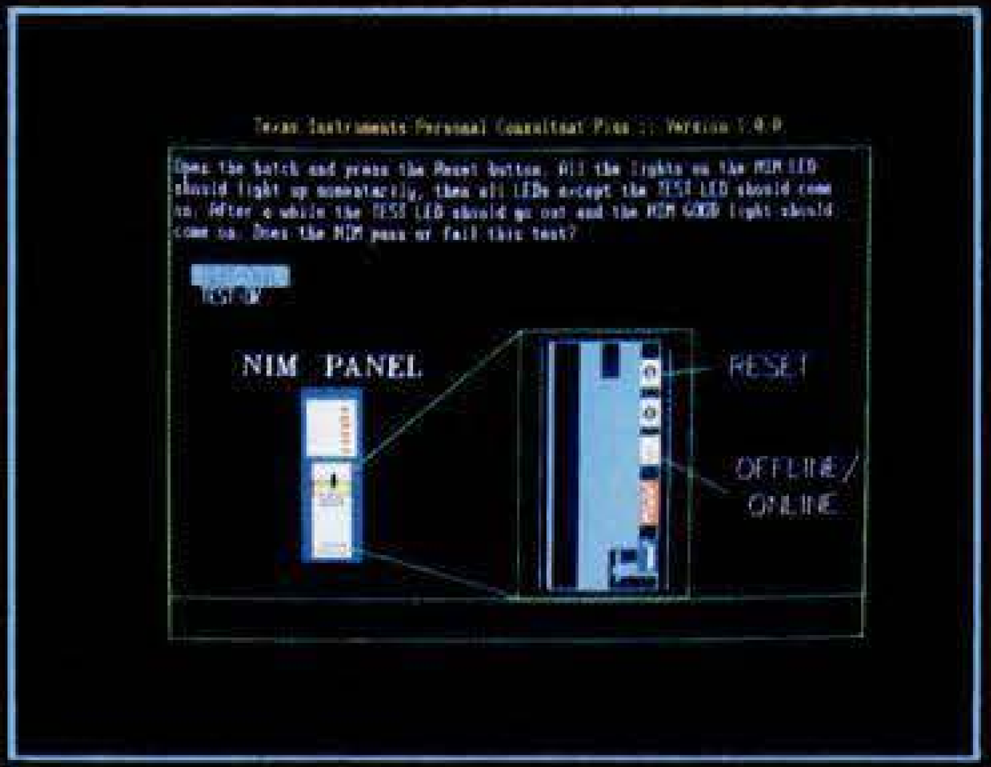
Possible Cause 1: 1 Salesforce Incentive Program
Recommended action 1: 1 Overrides on stereo sales above quota
2:

Possible Cause 2: 3 Merchandising Allowance Program
Recommended action 1: 3 Extend program to stereo & video disk
2: 4 Increase sales calls

Possible Cause 3: 2 Effect of Advertising
Recommended action 1: 2 Keep up the good work !
2:

Save, Delete message, Change Memo, Change Routing or Quit? (S/D/CM/CR/Q)

F2=Help



Texas Instruments Personal Consultant Plus :: Version 1.0.0

Forecasting and management control are powerful applications for expert systems in business. Above, Trigger's graphic displays show how well sales are doing; textual displays suggest ways in which to improve sagging sales.

Hardware failure is diagnosed by the Personal Consultant Plus. Future systems could do the same for software.

chaining to arrive at a conclusion based on facts and backward chaining to derive the facts from a known conclusion.

"When it runs out of rules before reaching a conclusion," Wallace continued, "it asks you another question."

In my first try, I told the system that a light would not come on as it should. Then I answered the questions to indicate that all the electronics worked properly. Result: The system correctly told me to change the bulb. That's not a milestone in electronic troubleshooting, but in subsequent tries I gave erroneous answers deliberately. The system surmised something was wrong: It decided that three separate failures were needed to create the situation I described. That's unusual, so it then inferred that I had made a mistake in one of my answers by offering me a chance to answer some more questions.

For real-life problems, the question-mark reply becomes important to all expert systems. "In many decision-making situations the user won't know the answer," says Davis. "One of the most important characteristics of these programs is that there is no single question that it must absolutely have to get an answer. It will do its best to make the best decision based on the information it has."

Another, less obvious, feature is called transparency: It allows you to see the lines of reasoning that the expert system used to arrive at an answer. "The user can ask *Why?*" says Davis, "and the program shows the rules it used. Or he can ask *Why didn't you suggest?* and the program shows the rules that changed its mind. Or he can ask *How would you decide?* and the system tells the user the rules it would use in that situation."

Asking a system to predict what would apply *if* something were to occur is a bit like organized prophecy. In businesses—especially those that deal with numbers—it's called forecasting.

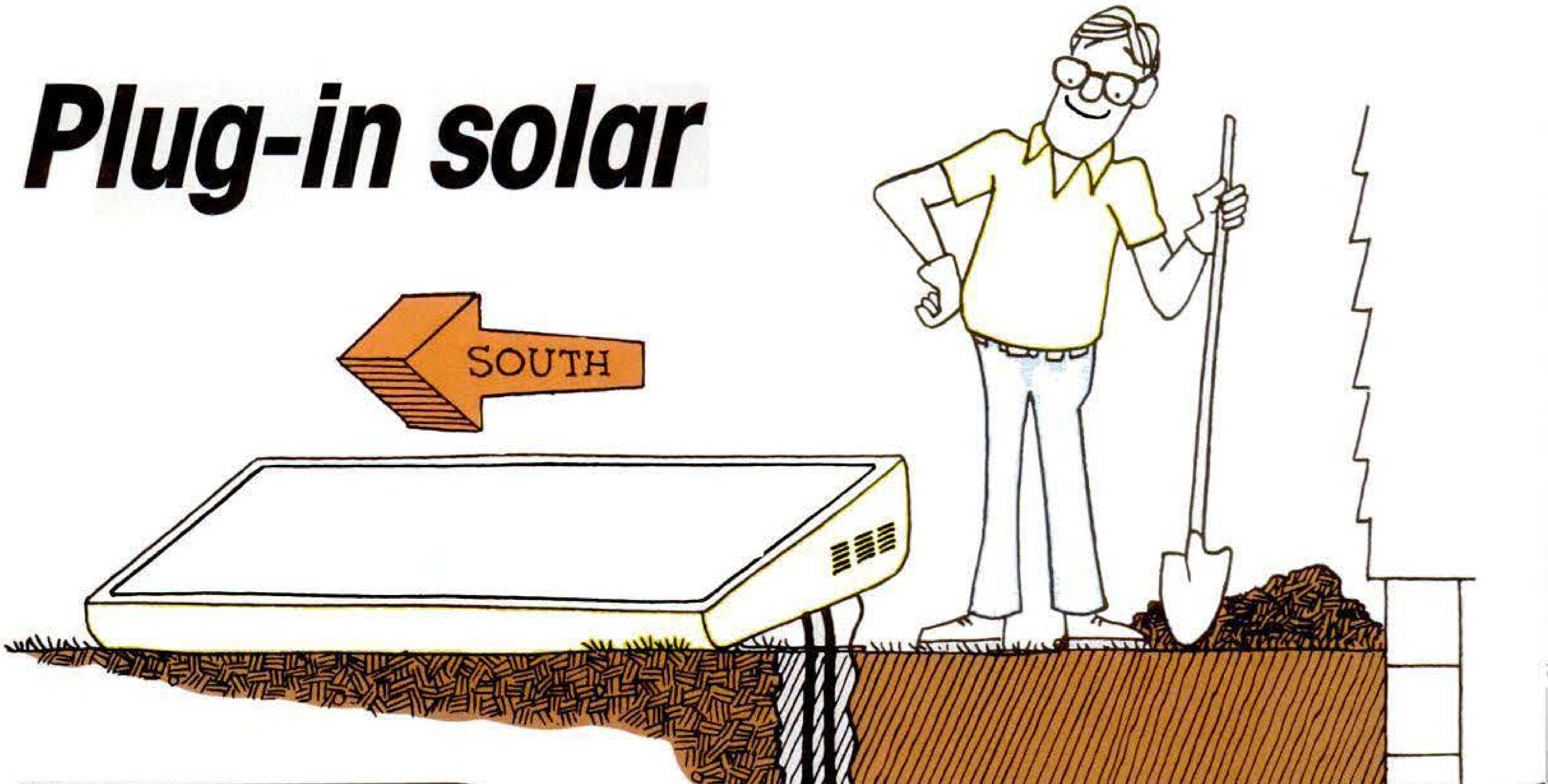
"Consider on the one hand you have a spread-sheet program," says Davis, "and on the other you have a spread-sheet program and a financial expert. With one you can do calculations and answer interesting questions. With the other, you'll have, as well, the judgment to know what questions to ask."

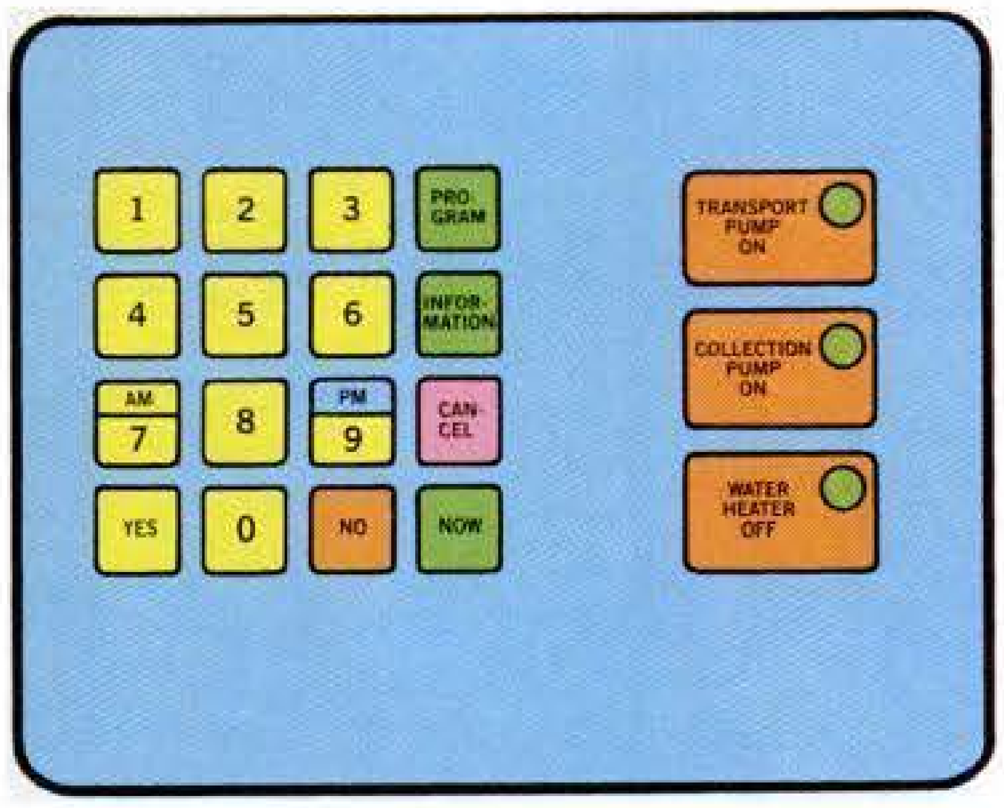
Programs like Expert Ease and Wizdom PX learn from experience. You enter sample data across a line—much like a spread sheet—and the system attempts to form rules. Though that does not limit their use to numbers, it does let expert systems more easily take on such jobs as financial advisor, investment counselor, sales and marketing strategists, and banking. It can go from acting as a teller to making the decisions of a loan officer.

At present, however, it is premature to determine just how well expert systems will perform in these or any other jobs. "With almost any new tech-

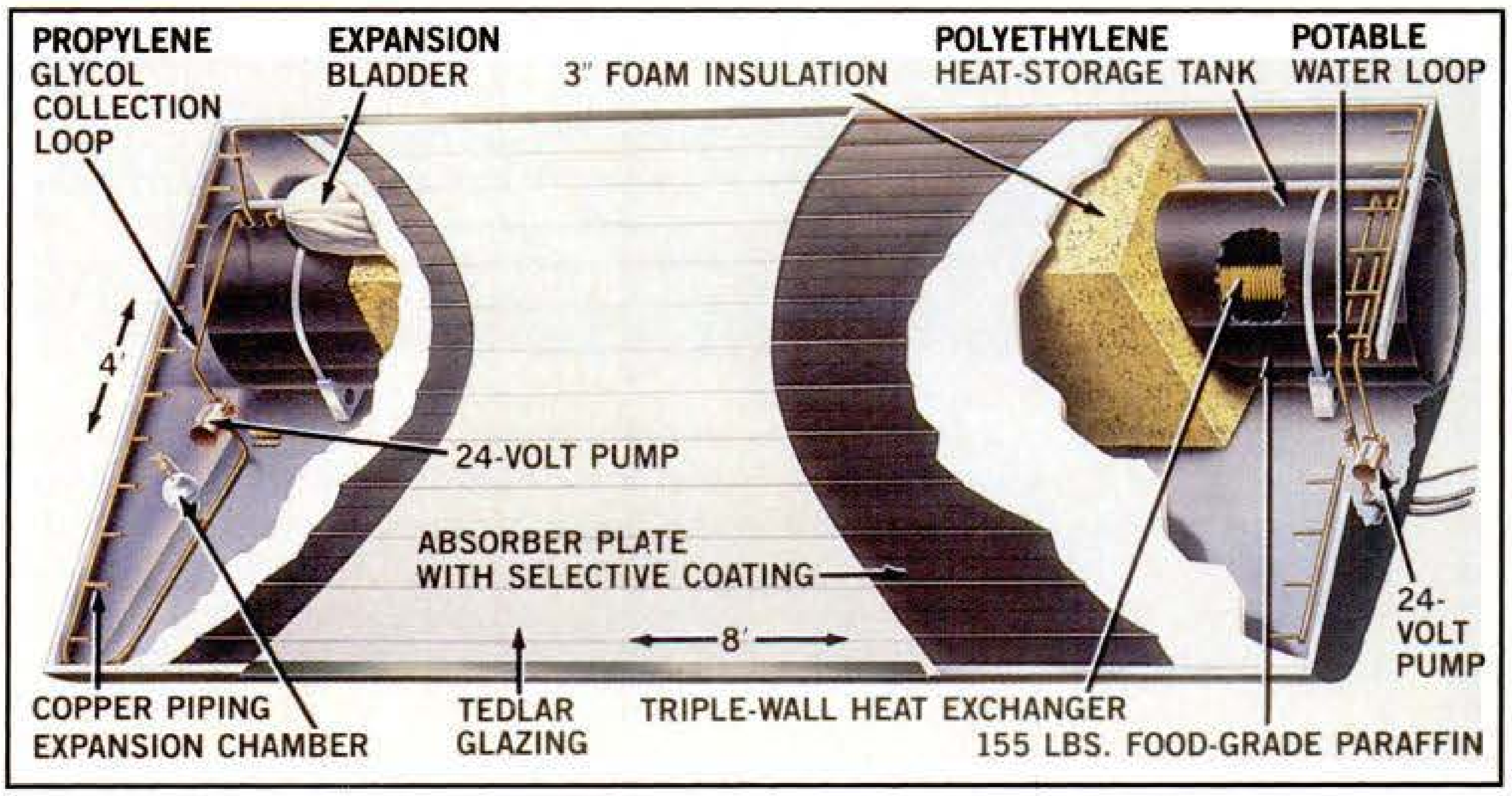
[Continued on page 116]

Plug-in solar




1
2
3
PRO-GRAM
4
5
6
INFOR-MATION
AM 7
8
PM 9
CAN-CEL
YES
0
NO
NOW
TRANSPORT PUMP ON
COLLECTION PUMP ON
WATER HEATER OFF

The control unit's computer-synthesized voice talks you through programming five operating modes: "simultaneous" mode uses both solar and utility heated water; "time interval" uses utility heat one hour before peak use periods; "solar priority" uses all solar heat before switching to utility; "vacation" prevents utility from switching on; "now" overrides all programs for two hours. Press the information button, and the unit verbally tells you present temperatures in the collector, storage, and water heater.


PROPYLENE GLYCOL COLLECTION LOOP
EXPANSION BLADDER
3" FOAM INSULATION
POLYETHYLENE HEAT-STORAGE TANK
POTABLE WATER LOOP
4'
24-VOLT PUMP
ABSORBER PLATE WITH SELECTIVE COATING
8'
24-VOLT PUMP
COPPER PIPING EXPANSION CHAMBER
TEDLAR GLAZING
TRIPLE-WALL HEAT EXCHANGER
155 LBS. FOOD-GRADE PARAFFIN

Make a few simple connections, and this solar water-heating system is plugged into an existing electric water heater. If you move, you can take it with you. The system includes a collector, heat storage, and a control box that talks.

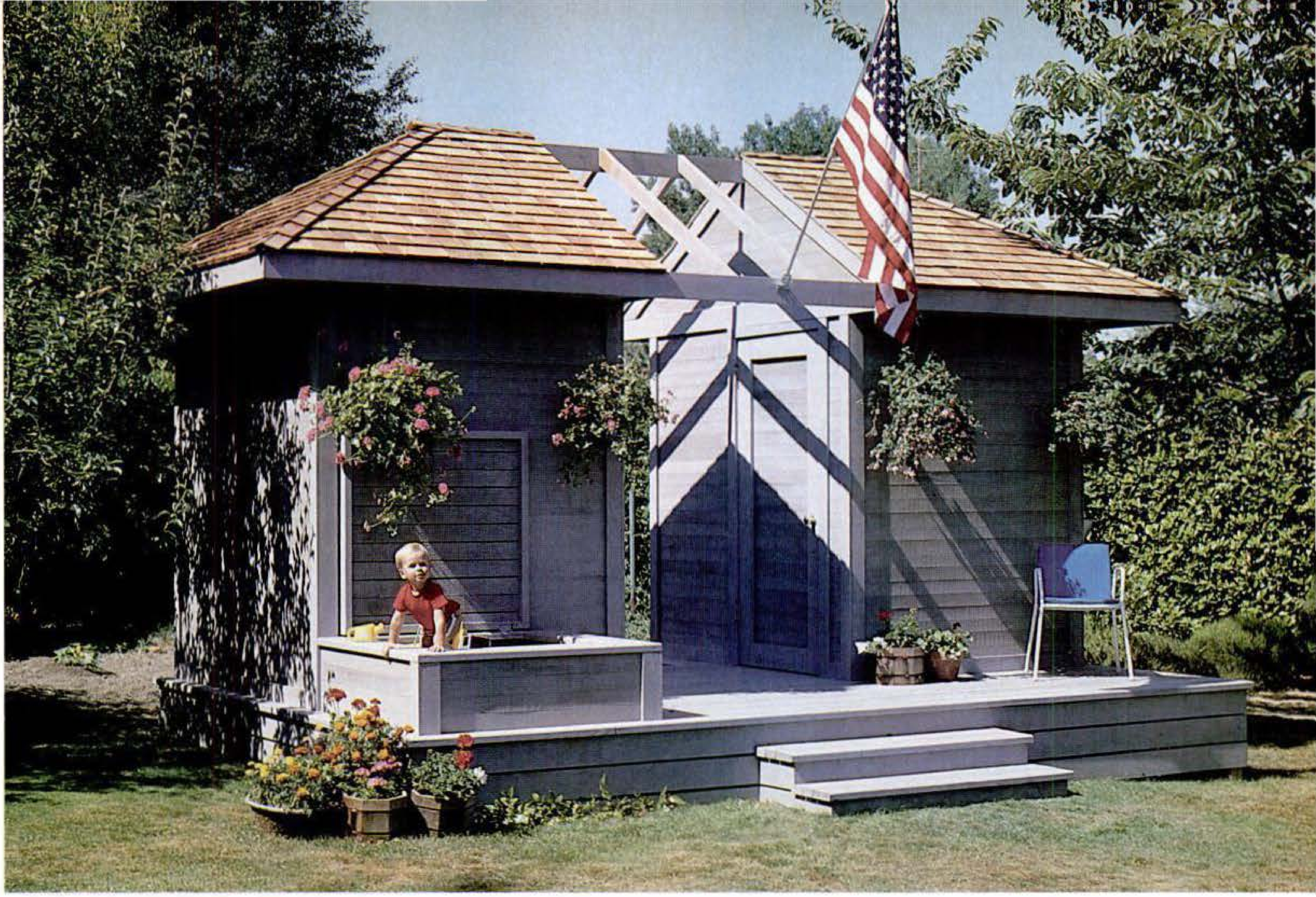
By RICHARD STEPLER

Bang! The sound, like a gunshot, startled me. But it was just Danny McCall's way of showing that the translucent plastic cover of his solar water heater could withstand sharp impacts. In this case, his foot.

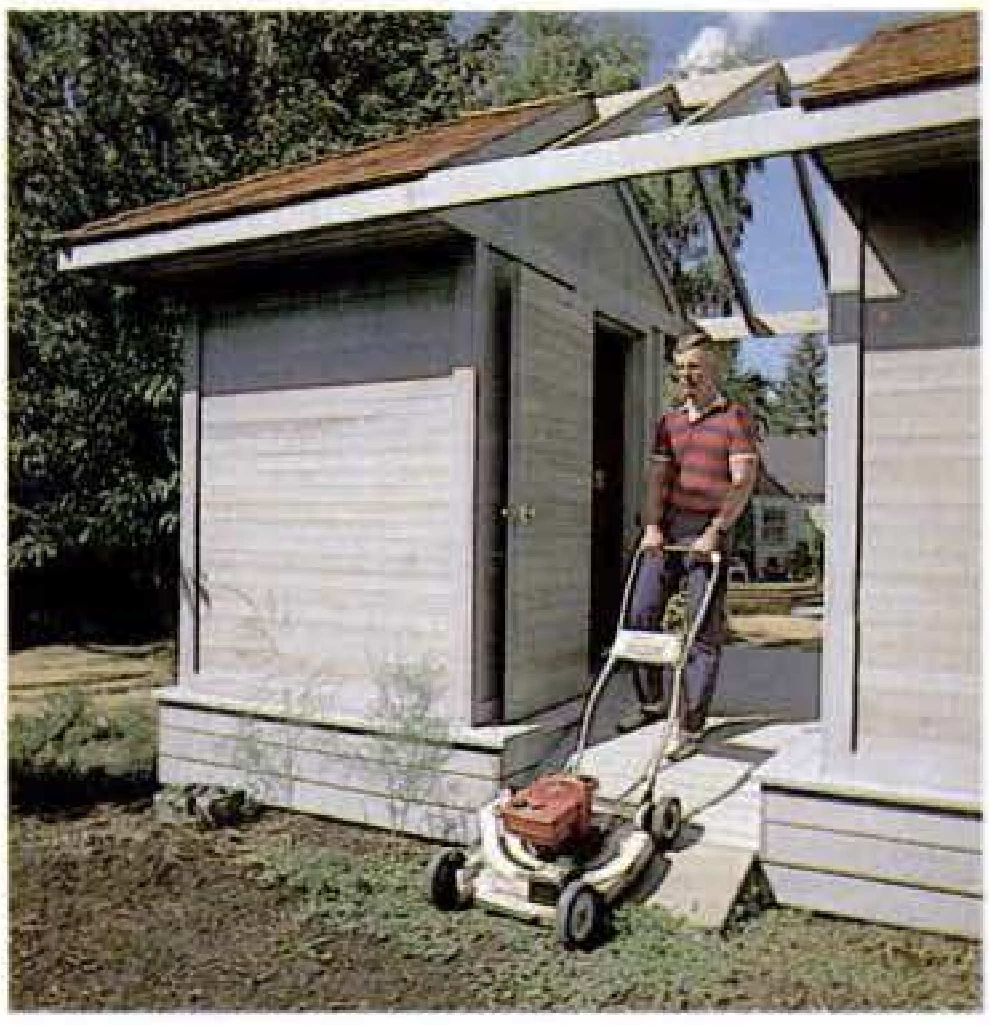
McCall was demonstrating his company's new solar appliance, the Energy Garden. "Most of the components are inside this four-by-eight-foot module," he explained. "That means you can take it with you if you move." Two 24-volt pumps are the system's only moving parts (see cutaway). The paraffin phase-change material, developed by NASA for the space shuttle, stores energy (changes from a solid to a liquid) at 125 degrees F. That means the system operates at lower, more efficient temperatures. The control unit can be programmed so that the sun provides from 40 to 70 percent of the energy to heat water, says McCall.

Connecting Energy Garden to an electric water heater is easy: Two plastic pipes from the unit are attached to a two-way connector at the water heater's drain.

Exemplar (Box 9027, Hickory, N.C. 28603) sells the Energy Garden Master Module for $2,495. Amplifier units (needed for families of more than two) cost $1,974. PS



Dual-storage garden shelter



A focal point for lawn and garden, this clever design organizes storage into separate sheds standing high and dry on a pedestal deck that includes a built-in sandbox.

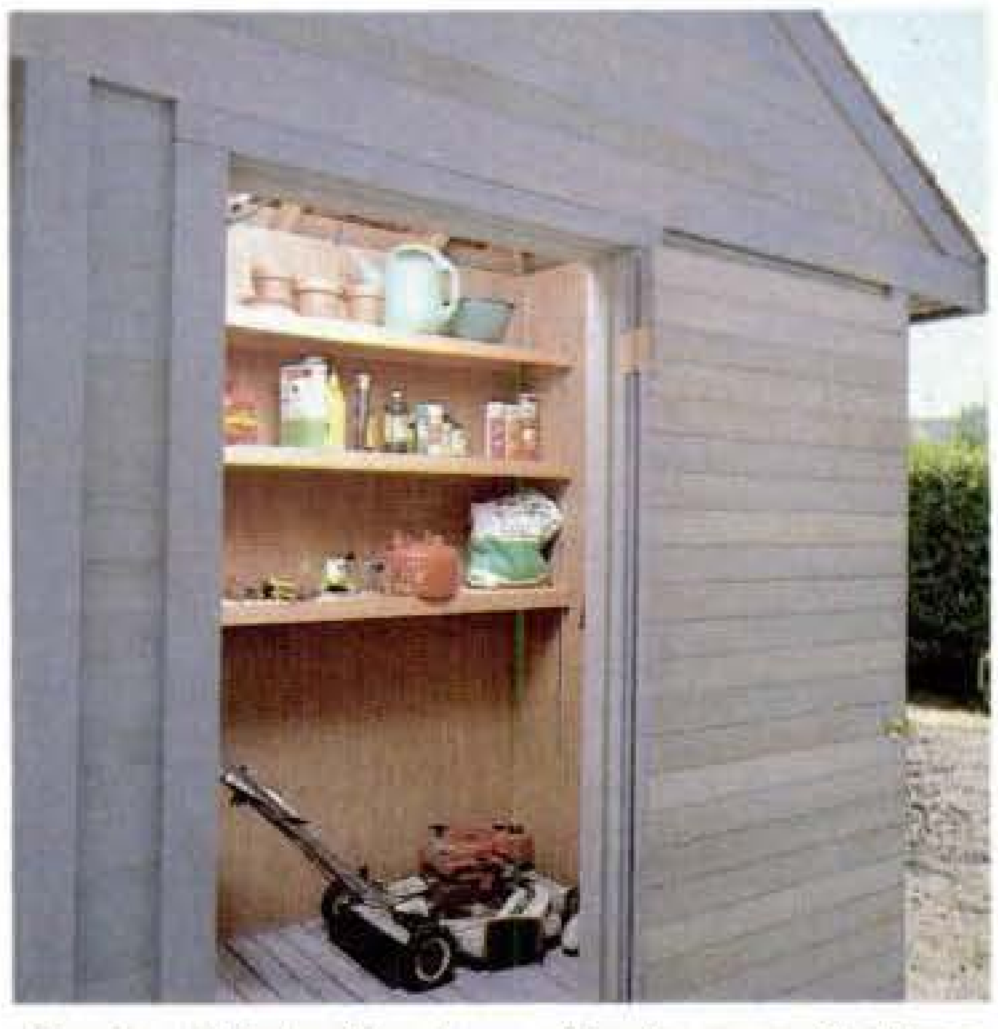
By CATHY HOWARD
Design by Julia Lundy, A.S.L.A.

There comes the day when your usual glance out the kitchen window stops you short with the realization that your backyard storage shack has become a blight on the landscape. When this happened to me, I researched commercial sheds and soon saw that I'd be replacing my eyesore with something nearly as bad.

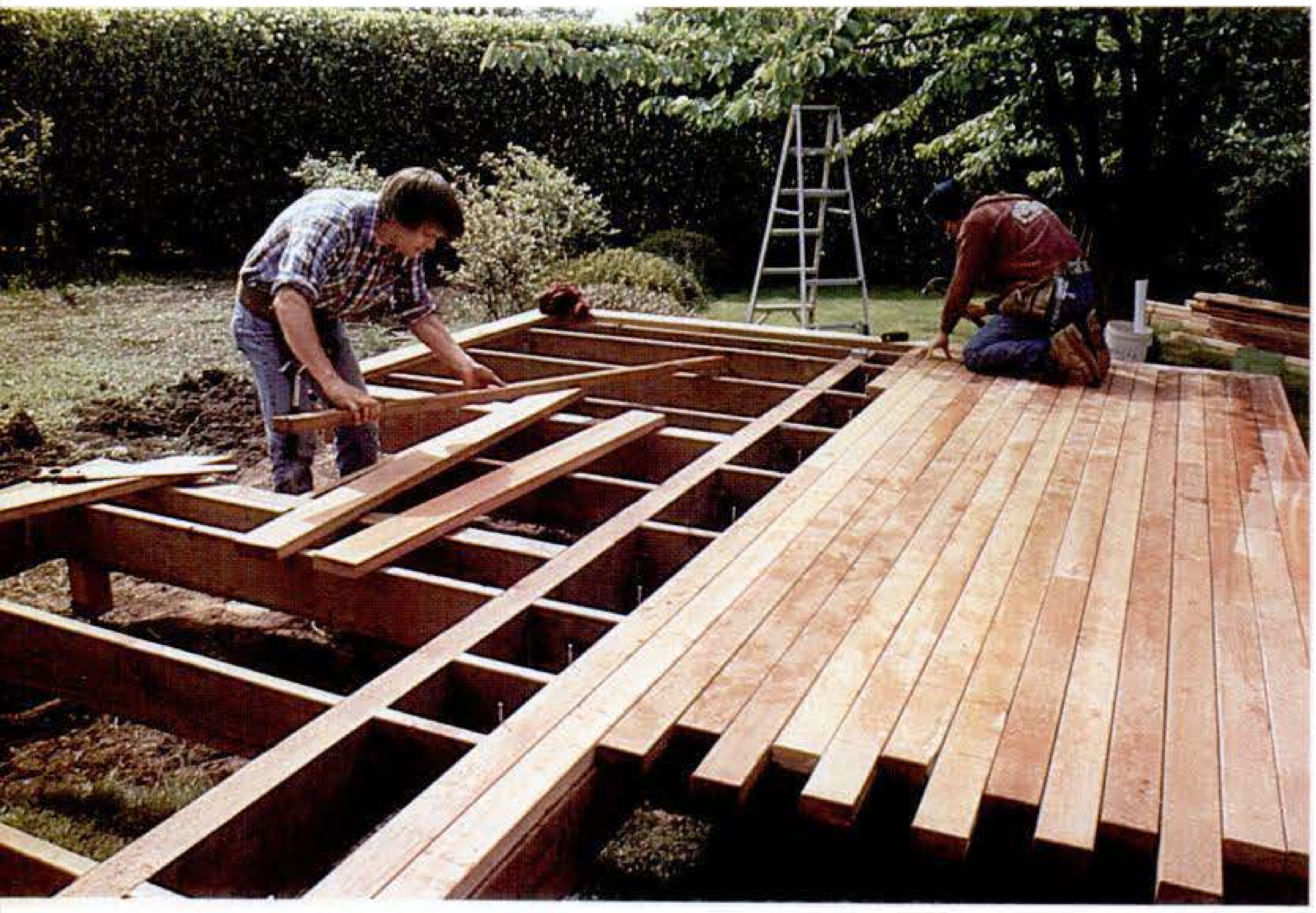
I wanted a shelter with the elegance of the lawn and garden it would serve, so I sought out a landscape architect. As we discussed what the structure could provide, the project grew into the split-shed design you see above. This automatically separates the lawn gear from the garden equipment and—by providing two relatively shallow, facing "closets"—avoids the jumble of a large one-room catchall. The breezeway between the sheds lightens the bulk and cuts off less of my kitchen-window view.

As a bonus, the structure gives focus to the outdoor play of our small children. The elevated deck gets them off the damp grass (and provides a great jump-off platform). We even built a big sandbox into one corner, with a hinged lid to keep out rain and debris. I've come to appreciate the veranda effect of the deck, and often rest here after outdoor chores (in a lawn chair that stores in one of the sheds) while over-

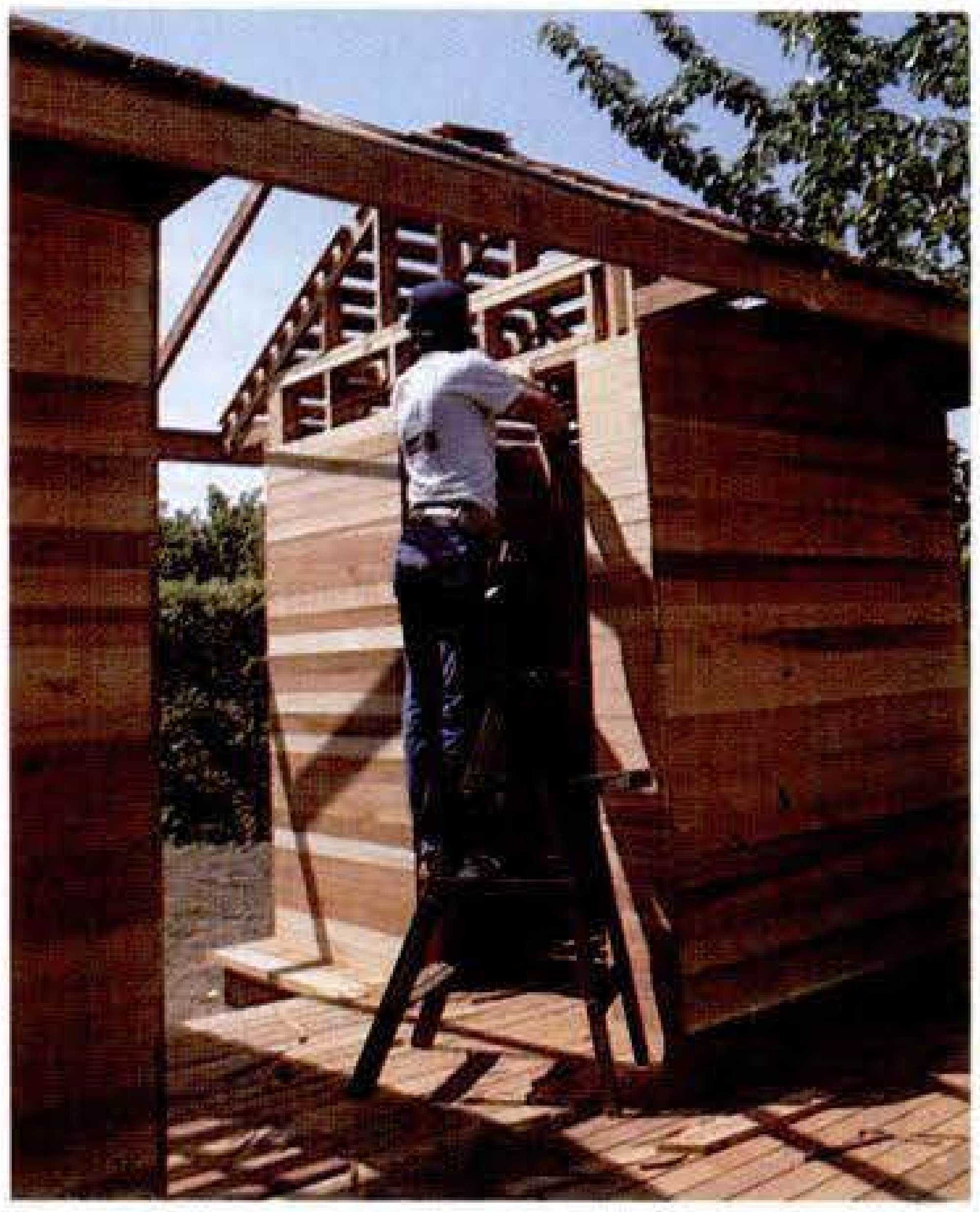
Continued



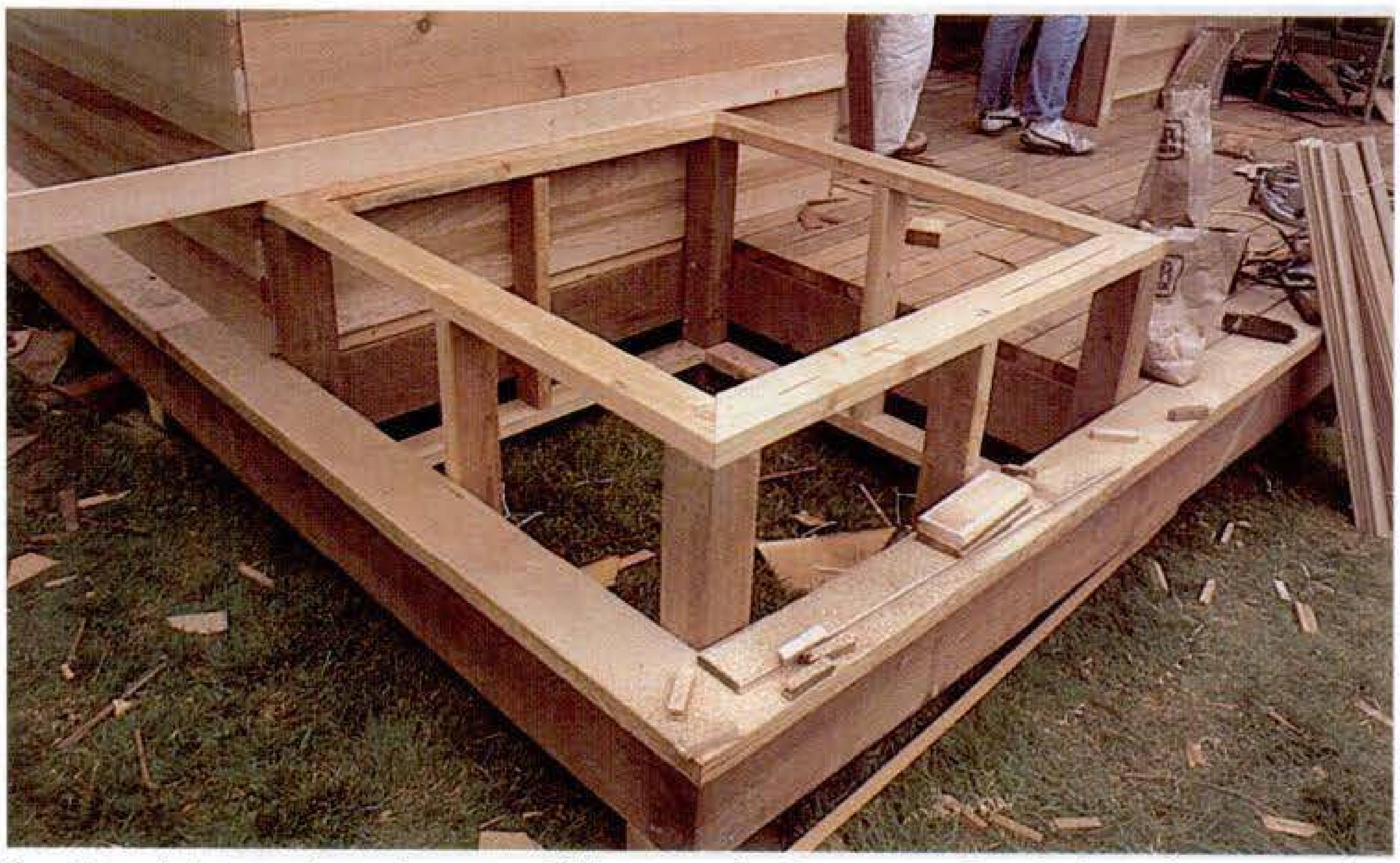
Tucked into the two sheds are shelves for storing lawn and garden equipment. There's floor space for a mower and tiller, which roll down the ramp.



Deck joists bridge beams supported by nine posts. Cedar 2×4s are nailed across the joists (left). The ragged forward edge will be trimmed with a circular saw to leave a square pit for the sandbox. Framing for the sheds is erected on sill plates spiked to the deck, then covered with cedar siding.



Siding is trimmed flush with the door openings, then run up the gables.



Sandbox/planter is a frame within a frame. You can add a sturdy cedar platform at a level that gives you the proper depth of sand or soil (see text).

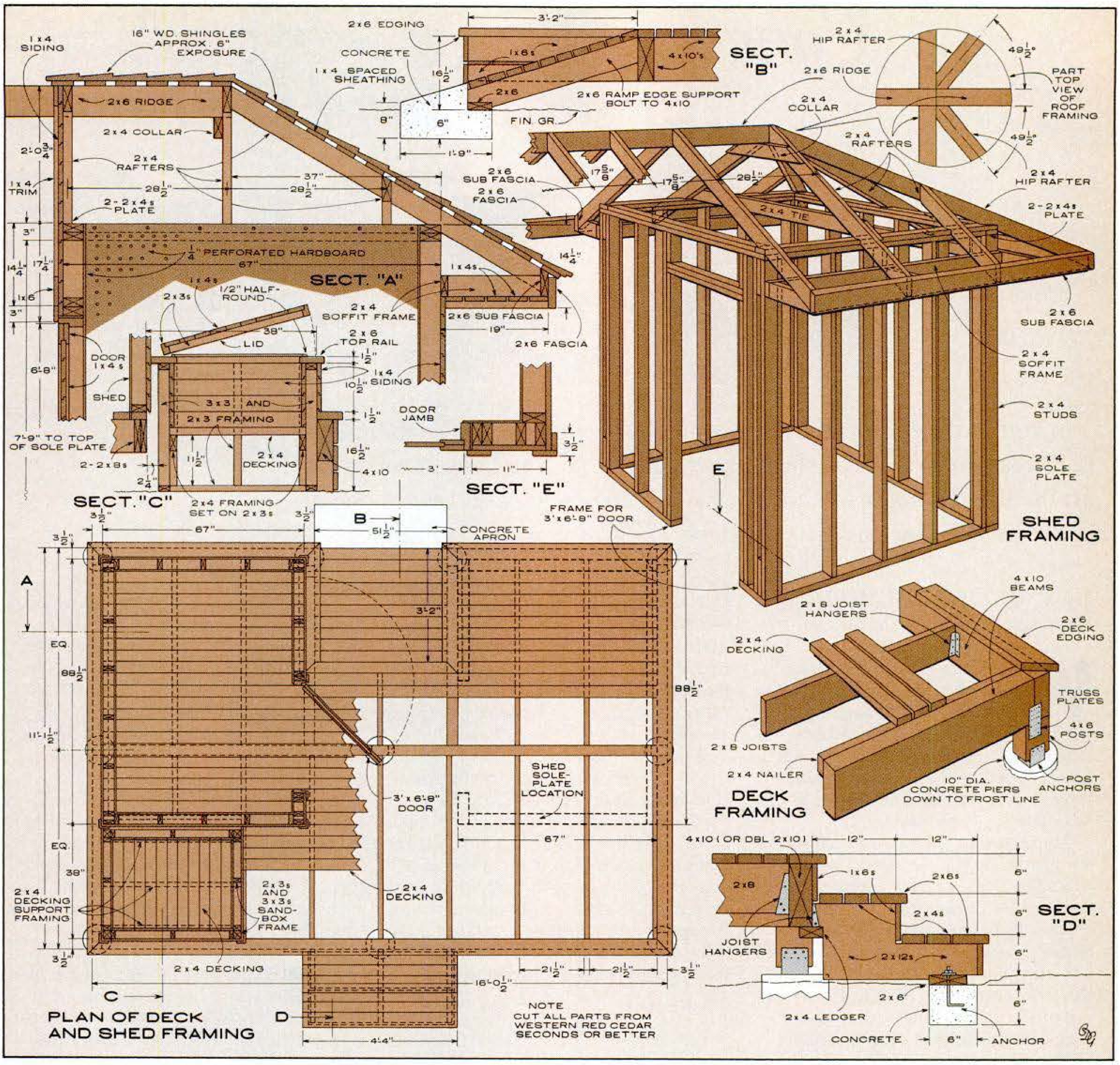
seeing the activities of my heirs. When they outgrow the sandbox, it will be converted into a large planter by replacing the sand with soil. The lid can then be removed or left permanently hooked up against the wall as a decorative framed panel.

We built the box by framing it right through the platform so that its frame rests on grade. (Following the advice of the Western Wood Products Assn., which worked with the designer, we used cedar or pressure-treated lumber throughout so ground contact would be no problem.) When we noted the depth of this pit, however, we decided it would take a wasteful volume of sand to fill it, so we installed a platform of cedar planks that would give us the proper depth of sand. The cracks between the planks allow for drainage, should the cover ever be left up during a rain. If we later want to plant an ornamental tree or large shrub here, I'll remove the platform and fill the pit with soil down to grade.

The two rectangular sheds measure about 5½ by 7½ feet, and the interior walls can be lined with tempered perforated hardboard to take a variety of tool hangers. We finished the exterior with a handsome silver-gray stain. My youngsters promptly claimed both sheds as playhouses and had to be evicted so we could plan our lawn and garden storage.

Construction procedures are shown in the dimensioned drawings and the photos above. The first step is to lay out and dig for the nine concrete piers. In areas subject to frost heave, it's best to drop these piers just below the frost line and pour some gravel into each hole to rest the tubular forms on before filling them with ready-mix concrete. Embed a post anchor at the top of each pier to take the 4 × 6 posts once the concrete sets. You don't even have to strip the forms before backfilling; if you apply a skirt as shown, the piers won't be visible, and they protrude only a few inches above grade anyway.

Using a string level, trim all nine posts to identical heights, then bridge them with three 4 × 10 beams as shown in the construction drawing. Check each beam with a carpenter's level as it is installed. This method ensures a level deck even if there's a compound slope to your yard. The height of the posts also determines the final height of the deck itself. The dimensions shown in the drawing are


1 x 4 SIDING
16" WD. SHINGLES APPROX. 6" EXPOSURE
2 x 6 EDGING
CONCRETE
1 x 4 SPACED SHEATHING
16 1/2"
1 x 6s
4 x 10's
SECT. "B"
3'-2"
2 x 6
8"
6"
FIN. GR.
1'-9"
2 x 6 RAMP EDGE SUPPORT BOLT TO 4 x 10
2 x 6 RIDGE
2 x 4 COLLAR
2'-0 3/4"
2 x 4 RAFTERS
37"
28 1/2"
28 1/2"
1 x 4 TRIM
2 - 2 x 4s PLATE
3"
14 1/4"
17 1/4"
1/4" PERFORATED HARDBOARD
67"
SECT. "A"
1 x 6
3"
1 x 4s
1/2" HALF-ROUND
2 x 3s
2 x 4 SOFFIT FRAME
1 x 4s
2 x 6 SUB FASCIA
19"
14 1/4"
2 x 6 FASCIA
38"
LID
2 x 6 TOP RAIL
1 1/2"
1 x 4 SIDING
10 1/2"
DOOR 1 x 4 s
6'-8"
SHED
3 x 3 AND 2 x 3 FRAMING
1 1/2"
DOOR JAMB
7'-9" TO TOP OF SOLE PLATE
11 1/2"
2 x 4 DECKING
16 1/2"
4 x 10
2 - 2 x 8s
2 1/4"
3'
11"
3 1/2"
SECT. "C"
2 x 4 FRAMING SET ON 2 x 3s
SECT. "E"
2 x 4 HIP RAFTER
2 x 6 RIDGE
2 x 4 COLLAR
2 x 4 RAFTERS
2 x 6 SUB FASCIA
2 x 6 FASCIA
17 5/8"
17 5/8"
28 1/2"
2 x 4 TIE
49 1/2°
PART TOP VIEW OF ROOF FRAMING
49 1/2°
2 x 4 HIP RAFTER
2 - 2 x 4s PLATE
2 x 6 SUB FASCIA
2 x 4 SOFFIT FRAME
2 x 4 STUDS
2 x 4 SOLE PLATE
E
FRAME FOR 3' x 6'-8" DOOR
SHED FRAMING
3 1/2"
67"
3 1/2"
B
51 1/2"
CONCRETE APRON
3 1/2"
A
3'-2"
EQ.
88 1/2"
88 1/2"
11'-1 1/2"
SHED SOLE-PLATE LOCATION
3' x 6'-8" DOOR
67"
EQ.
38"
2 x 4 DECKING SUPPORT FRAMING
2 x 3s AND 3 x 3s SAND-BOX FRAME
2 x 4 DECKING
3 1/2"
2 x 4 DECKING
21 1/2"
21 1/2"
3 1/2"
16'-0 1/2"
C
D
4'-4"
PLAN OF DECK AND SHED FRAMING
NOTE CUT ALL PARTS FROM WESTERN RED CEDAR SECONDS OR BETTER
4 x 10 BEAMS
2 x 8 JOIST HANGERS
2 x 4 DECKING
2 x 6 DECK EDGING
TRUSS PLATES
4 x 6 POSTS
2 x 8 JOISTS
2 x 4 NAILER
10" DIA. CONCRETE PIERS DOWN TO FROST LINE
POST ANCHORS
DECK FRAMING
4 x 10 (OR DBL 2 x 10)
12"
12"
2 x 8
1 x 6s
2 x 6s
6"
2 x 4s
6"
SECT. "D"
JOIST HANGERS
2 x 12s
6"
2 x 6
6"
2 x 4 LEDGER
CONCRETE
6"
ANCHOR

DRAWINGS BY CARL DE GROOTE

for a deck that's three easy steps up from grade; this can vary to suit the demands of your site.

Joist hangers are the easiest way to install the 2×8s between the beams. Since this support framing is also hidden (once the 2×4 cedar decking is nailed on), you can use pressure-treated lumber here without any finish.

Outline the periphery of the deck with a ribbon of 2×6 cedar, mitered at the four corners. (The only break in this ribbon is to allow for the descent of the ramp.) Next, surface the area within this frame by nailing down cedar 2×4s. If you're including the sandbox/planter of our design, don't, of course, deck this corner. In nailing on the 2×4s, center any end joints on a joist, and stagger such joints so that they don't align. Be sure to place all deck boards "bark side" up so that any cupping as they weather will tend to shed water toward the cracks. A good rule of thumb is to use 16-penny nails as spacers between the last board nailed down and the next one to be applied.

Drive one nail into each joist the deck board crosses, in a zigzag pattern about an inch from each edge. When nailing near ends, it's best to pre-drill to avoid split-out. Use only aluminum or hot-dipped galvanized nails to avoid rust stains later. This also applies to nailing on your siding planks.

Once the deck is complete, you have a work platform on which to erect the shed framing. Frame all four walls of both sheds, then tie the two frames together with the framing for the hip roof. Lay out the ridge, cut 12 identical common rafters, and nail this assembly in place. Measure for the hip rafters and install as shown above. Various siding patterns are available, including beveled lap, if you want more surface texture.

It took nine bundles of cedar shingles to do this roof (plus two bundles of hip and ridge singles). Note that we skipped a roof deck, nailing on, instead, properly spaced lath to which the shingles were nailed. For an airy design, we left the space between the sheds unroofed, staining the two exposed rafters on each side of the continuous ridge to match the siding. If you prefer more shelter over the shed doors, extend the shingling—but consider a central skylight or two. PS

Concerned about air quality? Build your own air-to-air heat exchanger

You've insulated and caulked your house to keep the heat in. But perhaps you've trapped some nasty pollutants. You can use an air-to-air heat exchanger to change foul air for fresh, and save much of your heat. If you build it yourself, you'll also save a bundle.

By V. ELAINE GILMORE
Drawing by Adolph Brotman

Whole-house air-to-air heat exchangers usually cost $350 to over $2,000 [PS, Jan. '83]. But with a few tools and a bit of time you can build this one for around $200. How much time? Northern Scientific, the company that developed the plans, says one to three weekends.

An air-to-air heat exchanger is a simple device that transfers heat from a warmer to a cooler airstream but does not let those airstreams mix. The result: It brings fresh air into your house, pre-warming the incoming cold air with heat from the outgoing stale air—or precooling fresh air in the air-conditioning season. Excess moisture and pollutants end up outside.

Most houses do not need a heat exchanger. They get more ventilation than they need—through cracks, holes, and leaky windows and doors. But houses that have been carefully caulked, weatherstripped, and wrapped in a vapor barrier can be too tight. Excessive humidity can build up inside. Worse, so can hazardous chemicals—formaldehyde, oxides of nitrogen, carbon monoxide, and radon, for example [PS, Oct. '80]. A heat exchanger can reduce their concentration without throwing a lot of costly heat out the window. This build-it-yourself model, the Northern 250, should recover 60 to 75 percent of the heat, says Dennis Rogoza, president of Northern Scientific. The efficiency of the one you build depends on how carefully you build it.

Commercial heat exchangers usually have metal cases and automatic controls. This one has a plywood cabinet and a timer to turn the fans on and off. The heat exchanger should be located where it's warm. Ducting connects it to inlet and outlet ports in various rooms of your house.

While you should be able to build the heat exchanger with the information here, you can order an 80-page manual for more details ($22.90 ppd from Northern Scientific, Box D, Minot, N.D. 58702). It includes extensive chapters on installing ductwork; balancing airstreams; operation, maintenance, and trouble-shooting; and step-by-step building instructions. (Before building, check your local code.)

The core

The core of the Northern 250 is made of double-wall plastic panels called Coroplast, available at many lumberyards ($20–$30 for a four-by-eight-foot panel). Thin plastic strips partition the gap between the two walls into small air channels. These become the fresh-air passageways. The stale-air passages are created by spacers: strips of Coroplast that you glue together to form double-thick stacks.

The company sells core kits, with all the Coroplast cut to size, for $94. If you prefer to build the core from scratch, buy three four-by-eight-foot panels of Coroplast. Cut them into six four-by-four-foot pieces (a utility knife will do), then cut five of these to 16 by 24 inches. The channels *must* run parallel to the 16-inch side. Twenty-nine of these will be the plates for the fresh-air passageways; the 30th will become the drain pan and air dam.

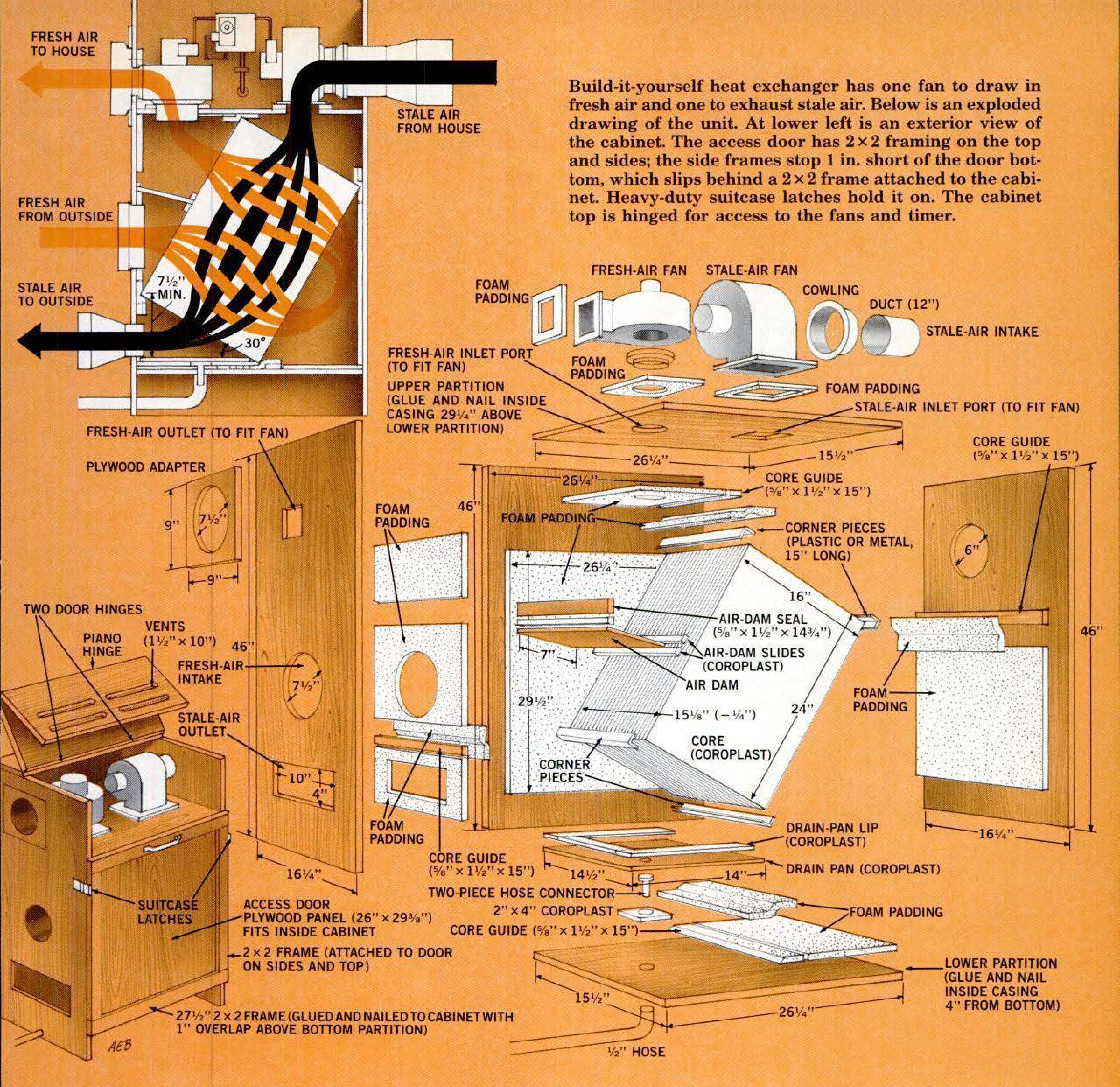
Cut the remaining four-by-four-foot Coroplast panel to form spacers. First cut the panel into six 16-by-24-inch pieces (channels paralleling the 24-inch side). Then cut the strips: Each spacer should be two channels wide, or about ⅜ by 24 inches. Cut 28 of these in half, forming 56 12-inch spacers. (Leave the remainder 24 inches long. Two will form the air-dam track.)

Glue the core parts together in a three-sided wooden box to ensure squareness. You can make it of ⅝-inch ply and later use it as part of the heat-exchanger cabinet. Protect the box from glue by taping wax paper inside.

Begin assembling the core by putting one 16-by-24-inch Coroplast panel into the corner of the jig. Tap in a few finishing nails along the edges to keep it in place. You'll need about six tubes of butyl adhesive. Put one in a caulking gun and run a bead of adhesive parallel to the two long sides of the panel, about ⅜ inch from the edges, and another bead 12 inches long in the center of the panel. Place a 24-inch spacer over each of the outside beads (¼ inch from the edge) and a 12-inch spacer in the center. Next, glue another set of spacers on top of the first. Follow with more adhesive and a second 16-by-24-inch Coroplast panel. Continue to stack panels and spacers until 29 panels have been stacked. Keep your stack straight. Place a weight on top, and let the core dry for 48 hours. Remove it from the jig, and glue on the angled corner pieces.

The cabinet

To build the heat-exchanger cabinet you need two sheets of ⅝-inch ply-


FRESH AIR TO HOUSE
STALE AIR FROM HOUSE
FRESH AIR FROM OUTSIDE
STALE AIR TO OUTSIDE
7½" MIN.
30°
FRESH-AIR FAN
STALE-AIR FAN
FOAM PADDING
COWLING
DUCT (12")
STALE-AIR INTAKE
FRESH-AIR INLET PORT (TO FIT FAN)
FOAM PADDING
FOAM PADDING
UPPER PARTITION (GLUE AND NAIL INSIDE CASING 29¼" ABOVE LOWER PARTITION)
STALE-AIR INLET PORT (TO FIT FAN)
FRESH-AIR OUTLET (TO FIT FAN)
PLYWOOD ADAPTER
26¼"
15½"
CORE GUIDE (⅝" × 1½" × 15")
CORE GUIDE (⅝" × 1½" × 15")
9"
7½"
9"
FOAM PADDING
46"
26¼"
FOAM PADDING
CORNER PIECES (PLASTIC OR METAL, 15" LONG)
6"
26¼"
16"
TWO DOOR HINGES
PIANO HINGE
VENTS (1½" × 10")
46"
FRESH-AIR INTAKE
7½"
AIR-DAM SEAL (⅝" × 1½" × 14¾")
AIR-DAM SLIDES (COROPLAST)
7"
AIR DAM
46"
29½"
15⅛" (−¼")
24"
FOAM PADDING
STALE-AIR OUTLET
CORE (COROPLAST)
CORNER PIECES
10"
4"
FOAM PADDING
DRAIN-PAN LIP (COROPLAST)
16¼"
16¼"
CORE GUIDE (⅝" × 1½" × 15")
14½"
14"
DRAIN PAN (COROPLAST)
SUITCASE LATCHES
ACCESS DOOR PLYWOOD PANEL (26" × 29⅜") FITS INSIDE CABINET
TWO-PIECE HOSE CONNECTOR
2" × 4" COROPLAST
FOAM PADDING
CORE GUIDE (⅝" × 1½" × 15")
2 × 2 FRAME (ATTACHED TO DOOR ON SIDES AND TOP)
LOWER PARTITION (GLUE AND NAIL INSIDE CASING 4" FROM BOTTOM)
15½"
26¼"
27½" 2 × 2 FRAME (GLUED AND NAILED TO CABINET WITH 1" OVERLAP ABOVE BOTTOM PARTITION)
½" HOSE
AEB

Build-it-yourself heat exchanger has one fan to draw in fresh air and one to exhaust stale air. Below is an exploded drawing of the unit. At lower left is an exterior view of the cabinet. The access door has 2 × 2 framing on the top and sides; the side frames stop 1 in. short of the door bottom, which slips behind a 2 × 2 frame attached to the cabinet. Heavy-duty suitcase latches hold it on. The cabinet top is hinged for access to the fans and timer.

wood, assorted hardware, and six square yards of ½-inch-thick urethane-foam carpet backing. The foam acts as a seal and a vibration damper.

Cabinet dimensions and assembly instructions are noted on the drawing. When the cabinet is assembled, paint the inside with two or three coats of marine enamel to protect it from moisture. When the enamel is dry, install the fans (with bolts, nuts, and lock washers, countersinking the bolt heads). Northern Scientific recommends Dayton fans (available from W. W. Grainger, Inc., 5959 W. Howard St., Chicago, Ill. 60648). Ask for model 4C447 (or larger 4C444, if needed).

Attach the cowling to the stale-air blower, and tape cowling and duct together with duct tape, leaving a space to dampen motor vibrations. The plywood adapter lets you mount a round duct collar (not shown) over the rectangular fresh-air outlet. Another round duct collar fits into the fresh-air intake port to connect it to your duct system. A duct boot with a four-by-10-inch opening on one end and a circular opening on the other fits on the stale-air outlet port.

You want the core to slip in and out easily without tearing the foam. Thus you should round off one corner of each core guide (the one nearest the core) and file down the square backs of the core corners. Locate and attach the core guides. Over each, staple a piece of foam as shown, and over the foam, staple heavy-duty plastic packing tape. Glue and staple the foam to the back.

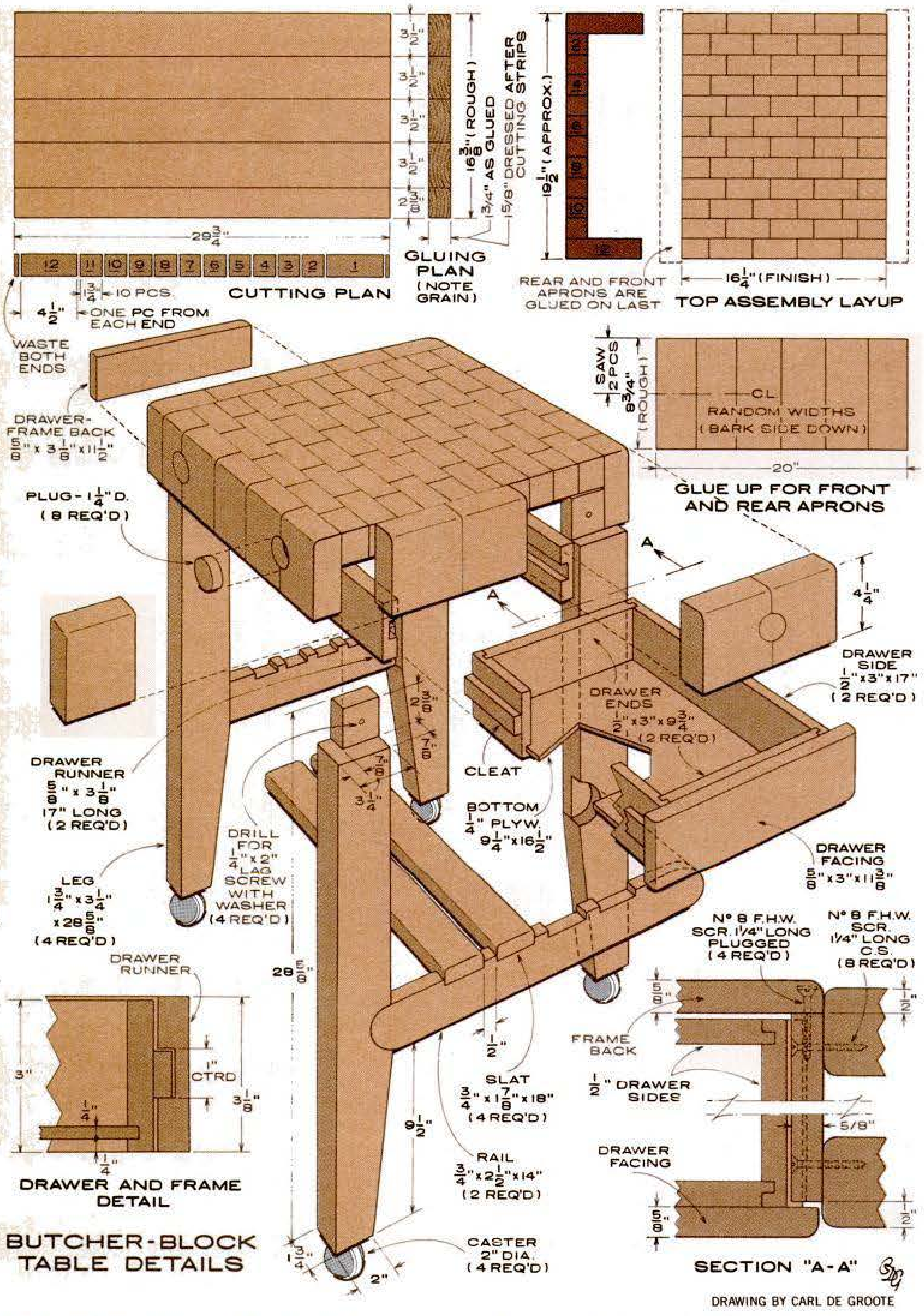
Make the air dam and tracks from Coroplast; the tracks are glued across the center of one 24-inch side of the core. Make the drain pan, gluing the lip to three sides of the base. Use a hose connector in the drain hole, and seal around it with silicone.

Line the sides of the cabinet and the access door with foam. The door should press firmly against the core. Cut and assemble the top cover. Then you're ready to finish the cabinet—any way you want. Wiring the fans and timer and installing the ductwork may require a professional. To tackle these tasks yourself, order the manual. PS

Butcher-block table

To many a home craftsman, the durable checkerboard surface of a well-made butcher block is a bench mark of woodworking skill. Here's how to make a cutting stand you can wheel from kitchen to patio.

By CY WEDLAKE
Photos by Jim Wedlake


3 1/2"
3 1/2"
3 1/2"
3 1/2"
2 3/8"
29 3/4"
12 11 10 9 8 7 6 5 4 3 2 1
1 3/4" ← 10 PCS.
4 1/2"
← ONE PC FROM EACH END
WASTE BOTH ENDS
CUTTING PLAN
16 3/8" (ROUGH)
13/4" AS GLUED
15/8" DRESSED AFTER CUTTING STRIPS
GLUING PLAN (NOTE GRAIN)
19 1/2" (APPROX.)
REAR AND FRONT APRONS ARE GLUED ON LAST
16 1/4" (FINISH)
TOP ASSEMBLY LAYUP
SAW 2 PCS
9 3/4" (ROUGH)
CL
RANDOM WIDTHS (BARK SIDE DOWN)
20"
GLUE UP FOR FRONT AND REAR APRONS
DRAWER-FRAME BACK 5/8" x 3 1/8" x 11 1/2"
PLUG - 1 1/4" D. (8 REQ'D)
A
A
4 1/4"
DRAWER SIDE 1/2" x 3" x 17" (2 REQ'D)
DRAWER ENDS 1/2" x 3" x 9 3/4" (2 REQ'D)
2 3/8"
7/8"
7/8"
3 1/4"
CLEAT
BOTTOM 1/4" PLYW. 9 1/4" x 16 1/2"
DRAWER RUNNER 5/8" x 3 1/8" 17" LONG (2 REQ'D)
DRILL FOR 1/4" x 2" LAG SCREW WITH WASHER (4 REQ'D)
DRAWER FACING 5/8" x 3" x 11 3/8"
LEG 1 3/4" x 3 1/4" x 28 5/8" (4 REQ'D)
N° 8 F.H.W. SCR. 1/4" LONG PLUGGED (4 REQ'D)
N° 8 F.H.W. SCR. 1/4" LONG C.S. (8 REQ'D)
DRAWER RUNNER
28 5/8"
5/8"
1/2"
FRAME BACK
1/2"
1/2" DRAWER SIDES
3"
1" CTRD
3 1/8"
SLAT 3/4" x 1 7/8" x 18" (4 REQ'D)
5/8"
1/4"
9 1/2"
1/4"
RAIL 3/4" x 2 1/2" x 14" (2 REQ'D)
DRAWER FACING
DRAWER AND FRAME DETAIL
5/8"
1/2"
BUTCHER-BLOCK TABLE DETAILS
1 3/4"
2"
CASTER 2" DIA. (4 REQ'D)
SECTION "A-A"

DRAWING BY CARL DE GROOTE

To build the butcher-block table top, see the text. Construction of the support structure is as follows: Rout out semicircular pockets for the shelf supports using a plywood template with a hole through it. Clamp two legs together, and center the hole on the joint. Turn the top upside down, and clamp a pair of legs in place, carefully squaring them to the top. Measure between the pockets for the shelf-support length. It's best to cut the slat dadoes from a piece of double-width stock and then split it. Curve the ends to match the pockets. Clamp the leg assemblies in place on the upside-down top. Measure and cut the slats, leaving them just a hair long. Round the slats, and glue them into place. Measure the distance between legs on the outside, and cut the drawer frame sides 1 in. shorter. Fasten the side frames and rear frame in place with screws. When the glue is set on the slats, remove the leg assembly for fitting the drawer. The drawer shown—with softwood sides and applied maple front—is neat, durable, and easy to build. A convenient knife holder can be installed inside the drawer (see photo insert, left).

Home craftsmen are often dismayed that a piece of store-bought furniture costs less than raw materials to duplicate it. But the value of a homemade butcher-block table can greatly exceed the cost of materials—and the quality will surpass that of anything you can get in a furniture store.

Traditional end-grain butcher-block tables instantly convey the impression that the builder has exceptional expertise. Yet, if a few simple procedures are followed, the job is quick. It's also wise to save the templates you make. I started out by building one for my daughter-in-law—but the table at right is number nine.

Try to buy your wood from a hardwood-lumber specialist. You'll pay less and have a better selection than you would at a lumberyard. Hard maple is the traditional material for end-grain butcher blocks. Avoid the "ring porous" woods like oak because it's hard to seal the end grain. Select clear planks that are free from brownish streaks. Tell the clerk that you want eight-quarter material (minimum 1¾ inches thick) in 60-inch lengths.

Maple machines well, but more slowly than many other woods, so sharpen your tools and tune your machines. It's especially important that your jointer knives are sharp because you'll be dressing across the side grain and you want to avoid "crack out" at the end of the cuts without having to turn the stock.

The next step is to rip and dress the edges of the top wood. Be careful here because this is the point at which you determine the ultimate beauty of the top. Lay the pieces on a bench and examine the end grain. Shuffle the pieces around to get the most pleasing grain pattern. Go for a sin-

you can build chop-chop

uous pattern that flows, as nearly as possible, from edge to edge without interruption.

Have everything ready for gluing before you start. A dry run to adjust the clamps is a smart idea. Use a yellow aliphatic glue such as Elmer's Professional or Titebond. Apply the glue to both surfaces, and flatten the bead with a thin paddle. Plenty of clamps and only moderate pressure should squeeze out glue along every line.

Detach the clamps after an hour or so—before the squeezed-out glue has completely dried. Remove most of the excess glue with a scraper. Now draw a diagonal pencil line across the top of the panel. This will make it easy to maintain the orientation of the segments after they're cut off.

Cut off a 4½-inch apron piece from one end, and reset the saw's fence for cutting the center segments. The last piece to come off is the 4½-inch blank for the opposite apron. You'll have to reset the fence twice, but you'll be maintaining the grain pattern and getting a smooth color gradation.

As the pieces come off the saw, lay them on the bench in their original order. The diagonal line will tell you whether you have mixed up the pieces. Number one end of each piece, and underline each number. Then rotate the pieces clockwise so each underline is on your left. Next, flip alternate segments 180 degrees so their marked ends face the opposite direction. You'll now have the underline on the left on both sides of your assembly, with all numbers in sequence—odd on one side, even on the other (see drawing). This procedure gives an interesting, repetitive pattern.

Dress the sides of the segments and aprons in the jointer to clean off the glue and form a good surface for adhesion. Small variations in individual segment thickness won't matter.

Now glue the top. It's best to glue the center pieces first and add the aprons later. Make sure the wood is protected from clamping marks. You'll save aggravation and sanding belts if you again take the assembled panel out of the clamps and scrape off the squeezed-out glue before it's set.

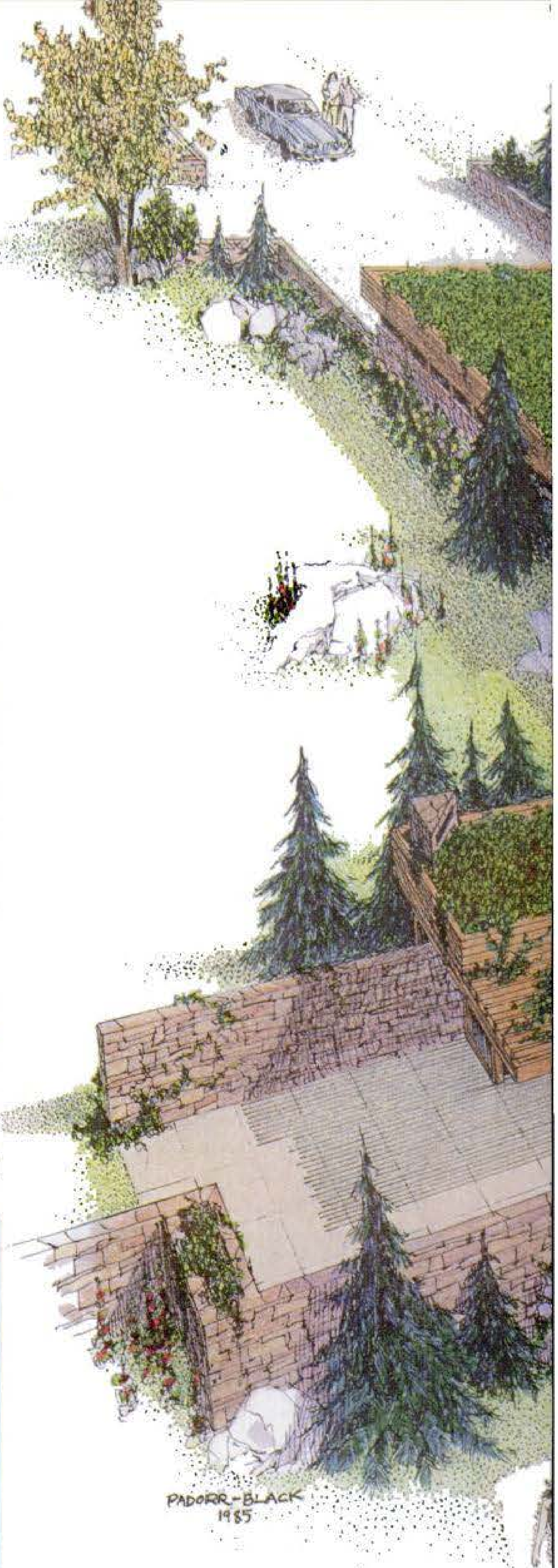
The procedure for building the front and rear aprons is similar to that employed for the rest of the top (see drawing). With the end aprons in place, do your first rough sanding on the top. Knock down the remaining glue, and

[Continued on page 117]

Popular Science leisure-home plan

Bermed T

Earth-sheltered, passive-solar-heated, and superinsulated, this house is inspired by Frank Lloyd Wright's Usonia designs. You can order plans for building your own version.


PADORR-BLACK
1985

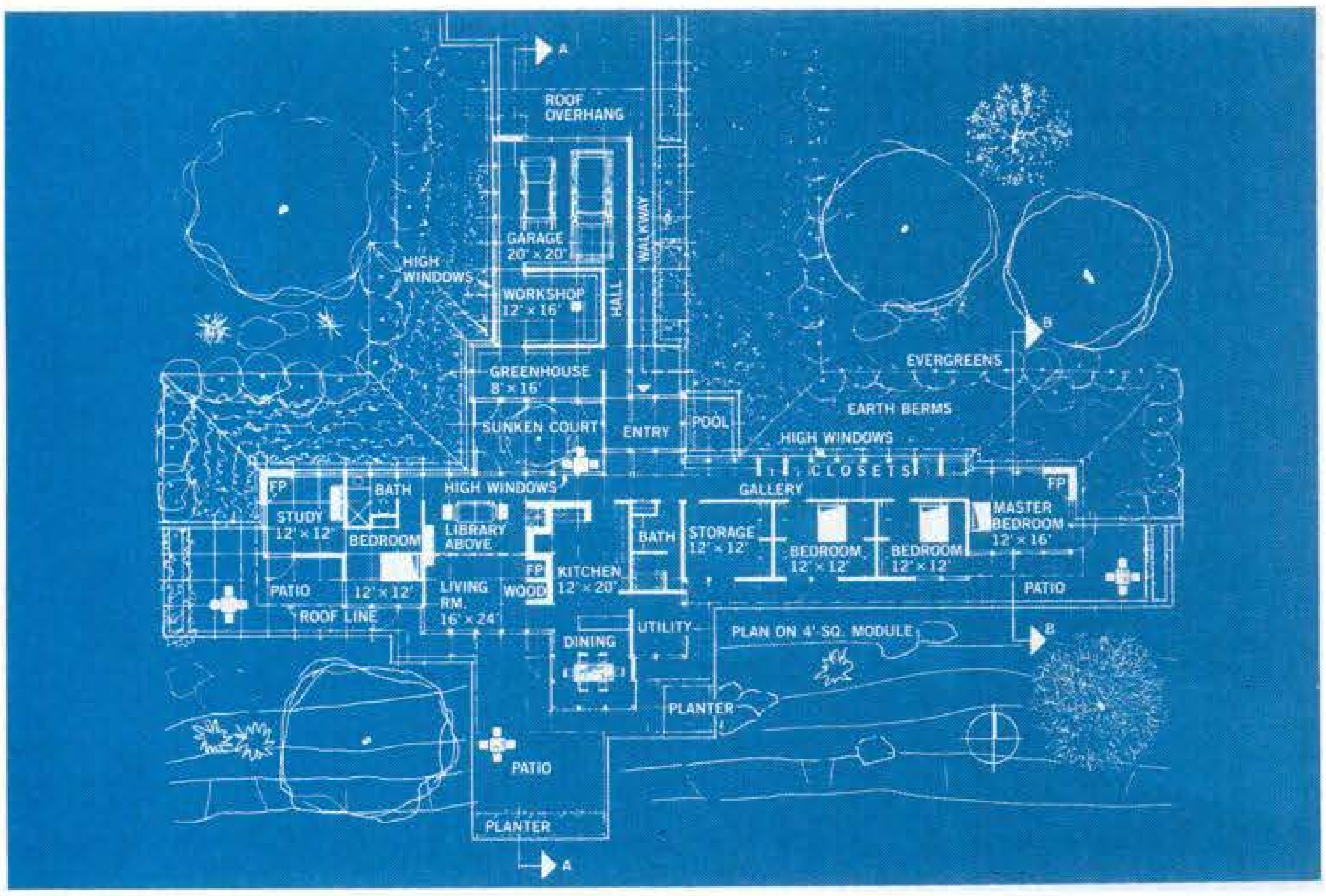
By Al LEES
Rendering by Randy Padorr-Black

The earth-sheltered homes POPULAR SCIENCE has commissioned from architectural designer Charles G. Woods have been among the most popular in this long-running series. This is Woods's ninth home for PS, and it may be his most spectacular. At nearly 3,700 square feet, it's larger than most, but that's *gross* footage, and it includes the large garage-workshop-greenhouse wing—the stem of the T.

Intended as an updated homage to Wright's famous Usonia homes, the Bermed T is designed on Woods's usual four-foot-square module, so can easily be reduced or increased in size. The floors and walls are concrete, the roof structure is exposed beam and plank, and the entire envelope is waterproofed with butyl rubber.

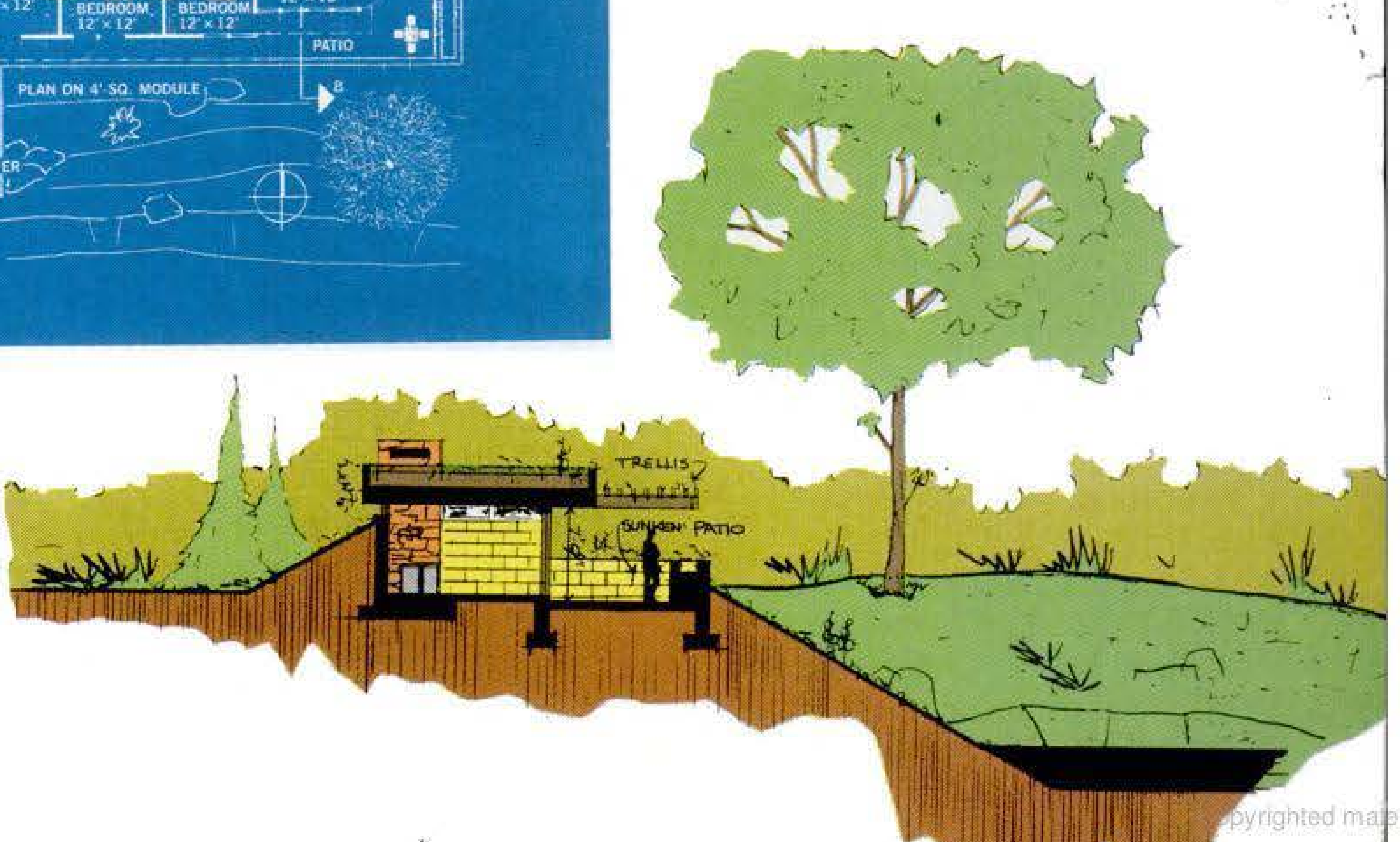
Skylights and inner courts bring sunlight to rooms that don't have windows along the long south-facing wall. Trellised overhangs shade this south glazing from the heat of the high summer sun, but let winter sunlight penetrate deeply to warm the structure's masonry mass. Earth berming along all north walls tempers cold winds and reduces winter heating needs.

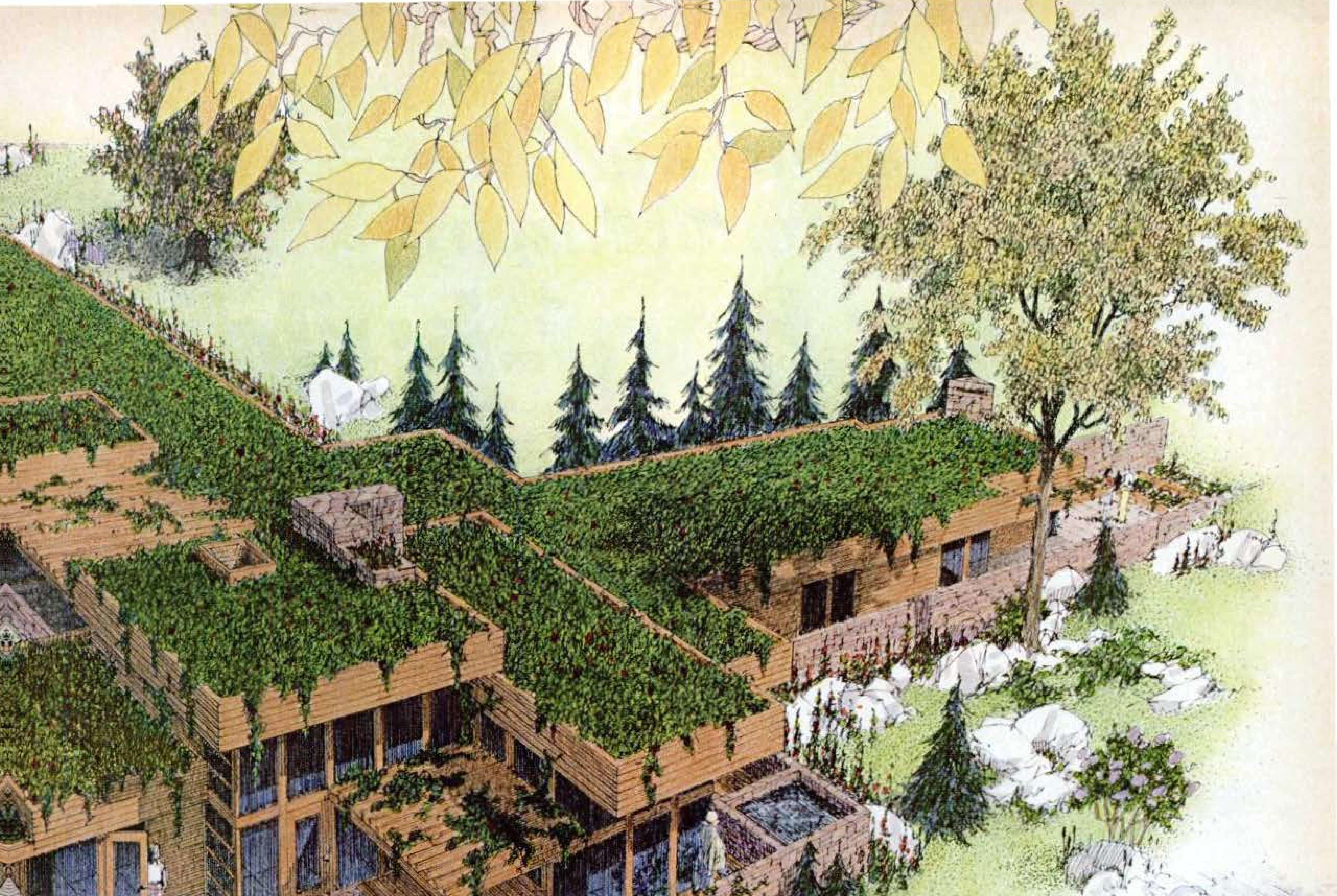
Note that the central section, where the three wings intersect, is two stories high. A library loft floats above the living room and is reached by spiral stairs. This extra level adds the spacial variety lacking in typical underground designs. PS

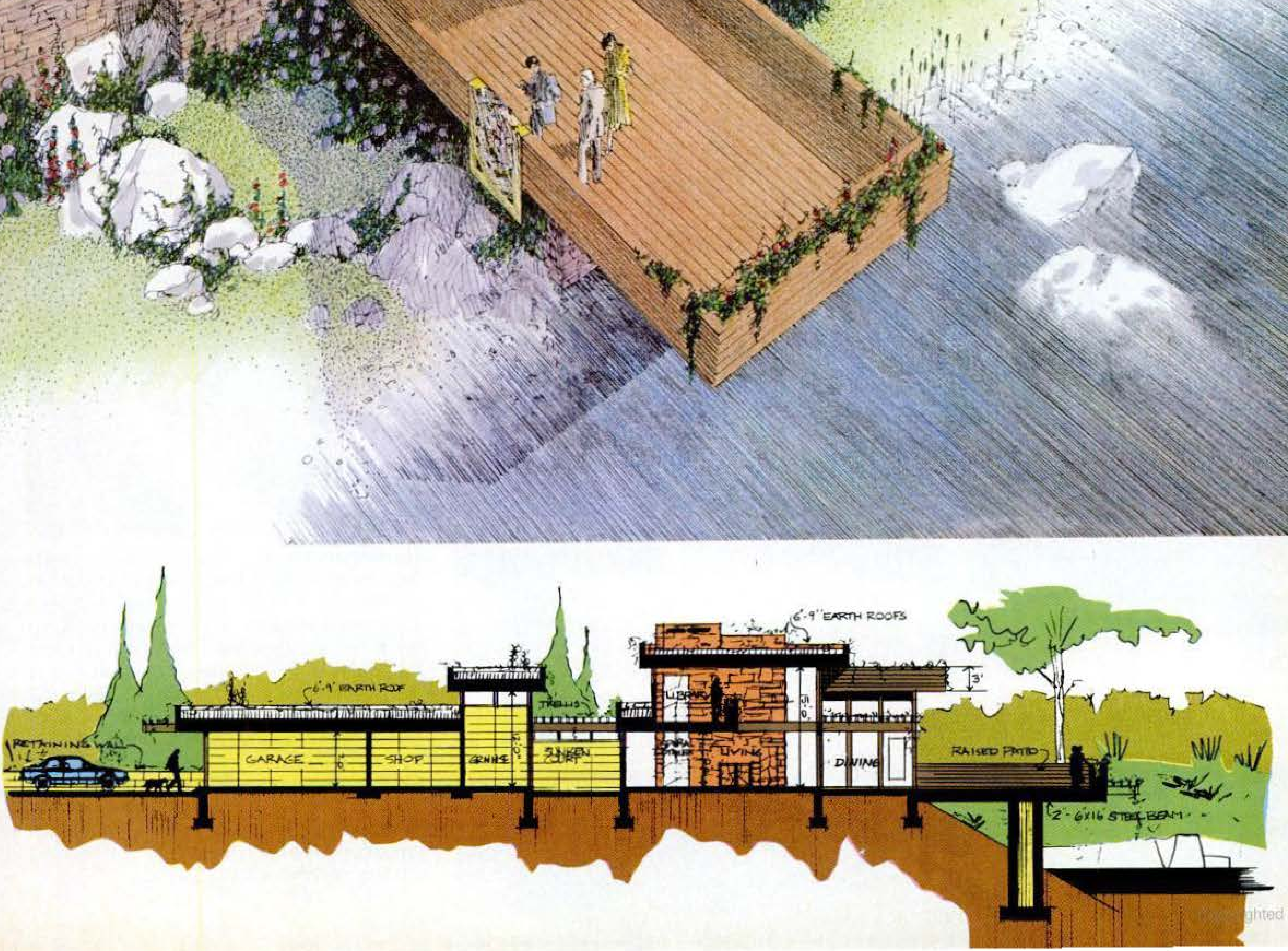

A
ROOF OVERHANG
GARAGE 20' × 20'
WALKWAY
HIGH WINDOWS
WORKSHOP 12' × 16'
HALL
GREENHOUSE 8' × 16'
SUNKEN COURT
ENTRY
POOL
EVERGREENS
EARTH BERMS
HIGH WINDOWS
CLOSETS
GALLERY
FP
BATH
HIGH WINDOWS
STUDY 12' × 12'
BEDROOM
LIBRARY ABOVE
PATIO
12' × 12'
ROOF LINE
LIVING RM. 16' × 24'
FP
WOOD
KITCHEN 12' × 20'
BATH
STORAGE 12' × 12'
BEDROOM 12' × 12'
BEDROOM 12' × 12'
FP
MASTER BEDROOM 12' × 16'
PATIO
B
UTILITY
DINING
PLAN ON 4' SQ. MODULE
B
PLANTER
PATIO
PLANTER
A

How to order your plans

One set of detailed plans for this house is $150. Each additional set is $25, and orders should include $15 for handling and postage. Address orders to Charles G. Woods & Assoc., RD 3, Box 538, Honesdale, Pa. 18431. Visa and MasterCard are accepted.

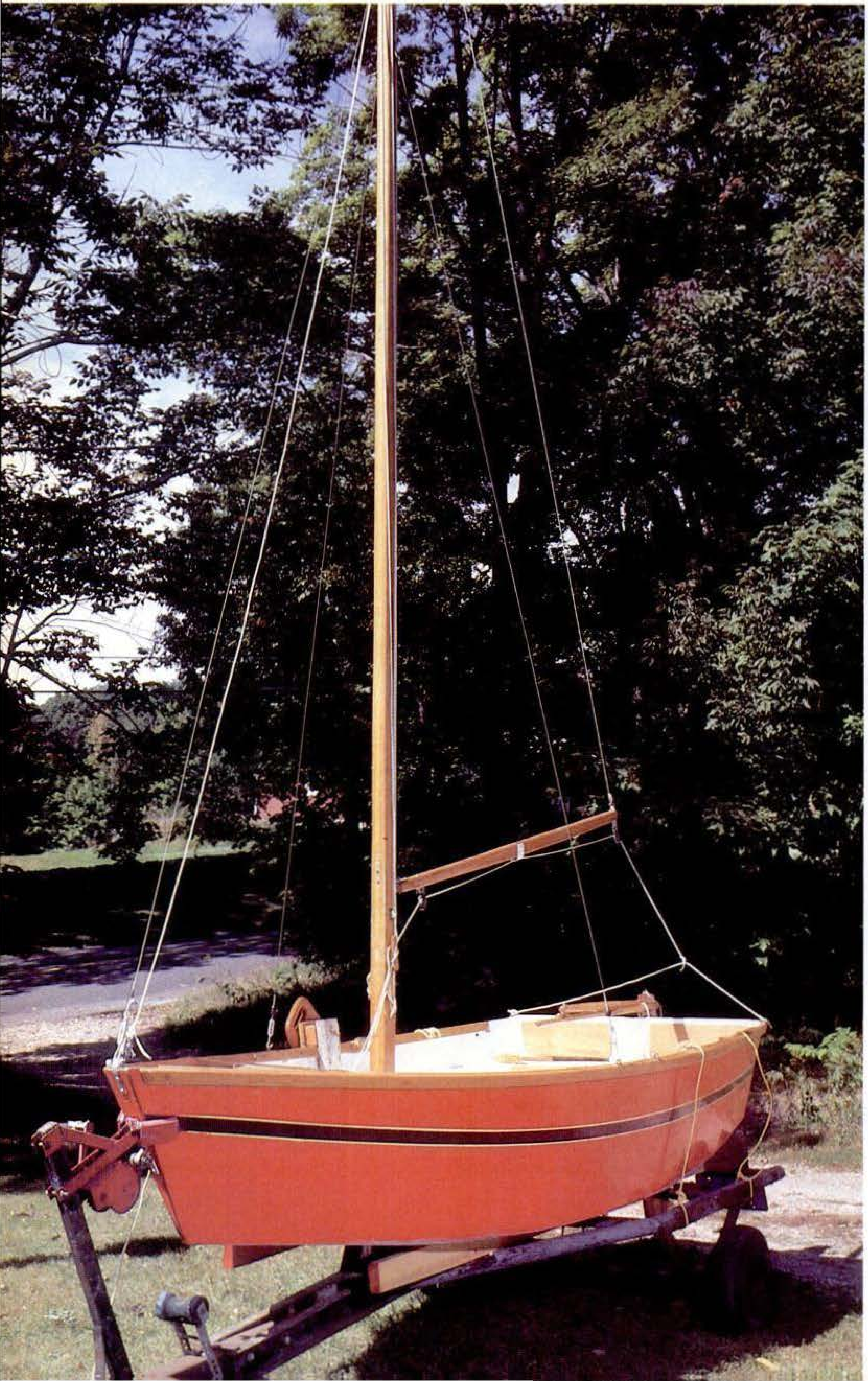

TRELLIS
SUNKEN PATIO




6'-9" EARTH ROOFS
6'-9" EARTH ROOF
TRELLIS
3'
LIBRARY
RETAINING WALL
GARAGE
SHOP
GRNHSE
SUNKEN COURT
LIVING
DINING
RAISED PATIO
2-6X16 STEEL BEAM

Kitchen counters and ultralight aircraft inspire clever boat-building

COLOR PHOTOS BY GREG SHARKO



Construction of a sailing skiff (left) begins with the fiberglass planks Henry Reluga masks out on a Formica-laminated surface (top). After brushing on a red gel coat and letting it dry, he lays down the first fiberglass mat. Then he brushes on clear resin, rollering it to penetrate the cloth (middle). He repeats this step several times to build up a plank, then peels it off the table. To join the planks, Reluga inserts them into a mock-up jig (above), tapes the joints on the outside, then lays up successively wider pieces of fiberglass roving to cement the seams.

Two home craftsmen have developed very different methods of building small boats—one using fiberglass, the other Kevlar aramid. The results: low-cost, easy-to-make home-builts that can match custom-built craft. Even if you never build a boat, these techniques may spark ideas for other projects.

techniques

By SUSAN RENNER-SMITH

Home boat builders are an inventive—even restless—breed. Those I've known build boat after boat, always trying new materials and methods.

"I've built dozens of dinghies," Henry Reluga says, standing on the deck of the redwood house he also built. From the deck I can see his current boat-building project, a 54-foot motorsailer that looks like Noah's ark come to rest on a Connecticut hilltop. Reluga's most recent dinghy, a bright-red 11-foot skiff, rests on a trailer nearby. "I've used it for two seasons," Reluga says as we walk down to inspect the shiny hull, "and I haven't done a thing to maintain it." The all-fiberglass boat looks brand new.

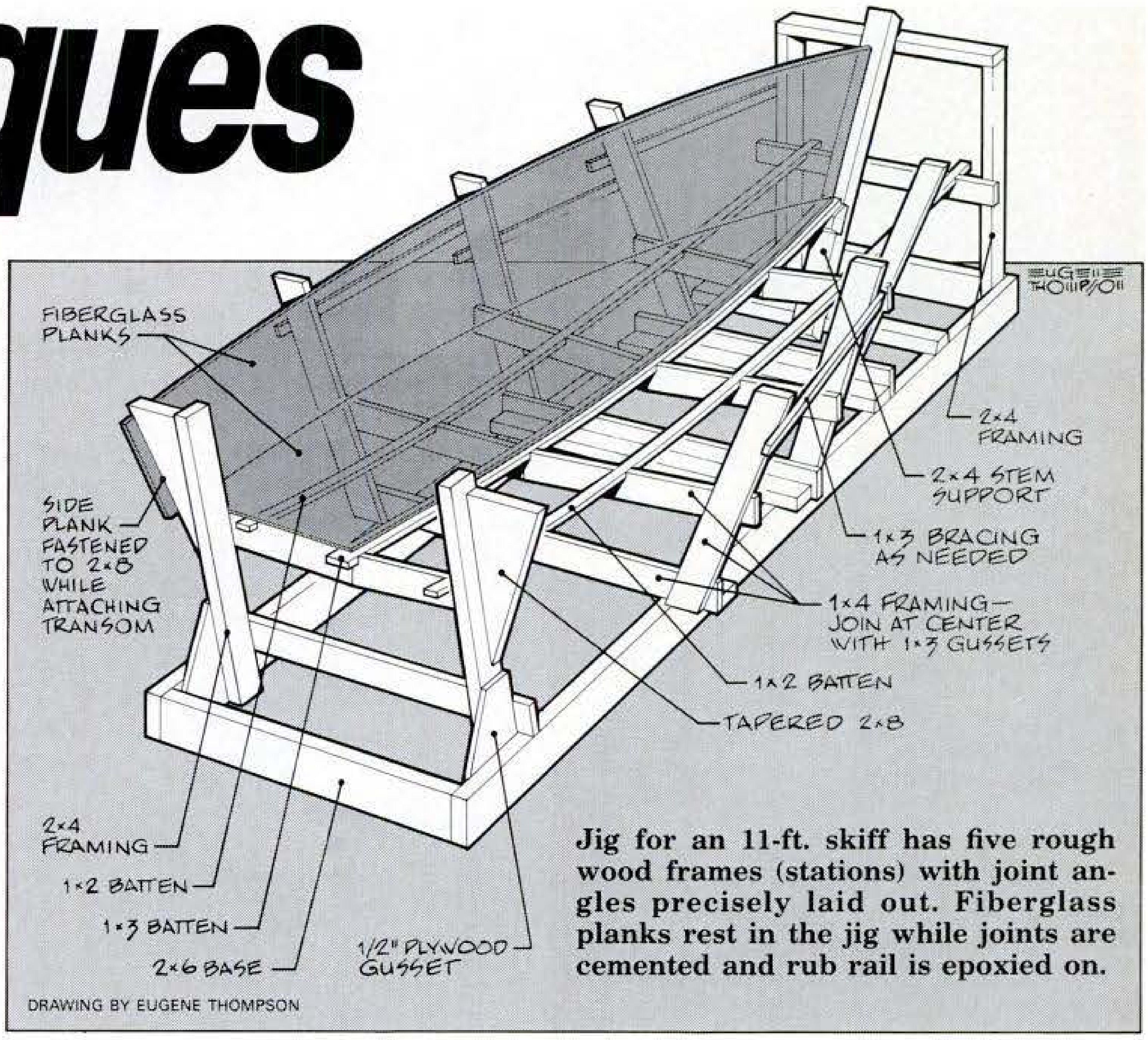
Reluga and Platt Monfort, another Yankee craftsman, have each developed radically simple methods for building small boats. Working independently (Reluga in Connecticut, Monfort in Maine), each sent POPULAR SCIENCE a report on their efforts. I found that their results can equal—or surpass—the quality of professionally built boats.

"There's not much competition in my line," Monfort tells me, referring to the aircraft-type aramid-and-polyester canoes he's built. "This is a new way to make a boat."

You have no desire to build a boat—ever? You may find other uses in your shop for the unconventional techniques developed by these craftsmen. To appreciate their cleverness, you should know how homemade boats are usually constructed.

The simplest way to build a dinghy is to glue together a plywood box, then paint it. "Here's what a plywood dinghy looks like after a few seasons," Reluga says, flicking a paint chip off a battered-looking craft. "I used to paint this every spring."

For a lower-maintenance craft you can coat the plywood with epoxy or face it with fiberglass cloth. "I've done both," Reluga says. "Either way, you have to do an enormous amount of sanding before you can paint."



Jig for an 11-ft. skiff has five rough wood frames (stations) with joint angles precisely laid out. Fiberglass planks rest in the jig while joints are cemented and rub rail is epoxied on.

DRAWING BY EUGENE THOMPSON

Another route to a maintenance-free boat is to build a mirror-image mold and then lay fiberglass mats inside it. Making the mold is tedious and tricky: All curves and angles must be reproduced precisely, then the mold surface must be faced with a smooth material and waxed so the fiberglass will lift off when cured.

"I didn't want to build a mold," Reluga says. "I needed a better way to build the boat I wanted—a hull that would be very strong, would last a good while, and would have a smooth surface."

Reluga devised a way to make the boat out of six fiberglass panels. His key insight was to use high-gloss Formica laminate as the surface for working with the fiberglass. "I tried using wetted Masonite hardboard the way custom boat builders do, but the gel coat [the tough resin finish coat] didn't come out smooth.

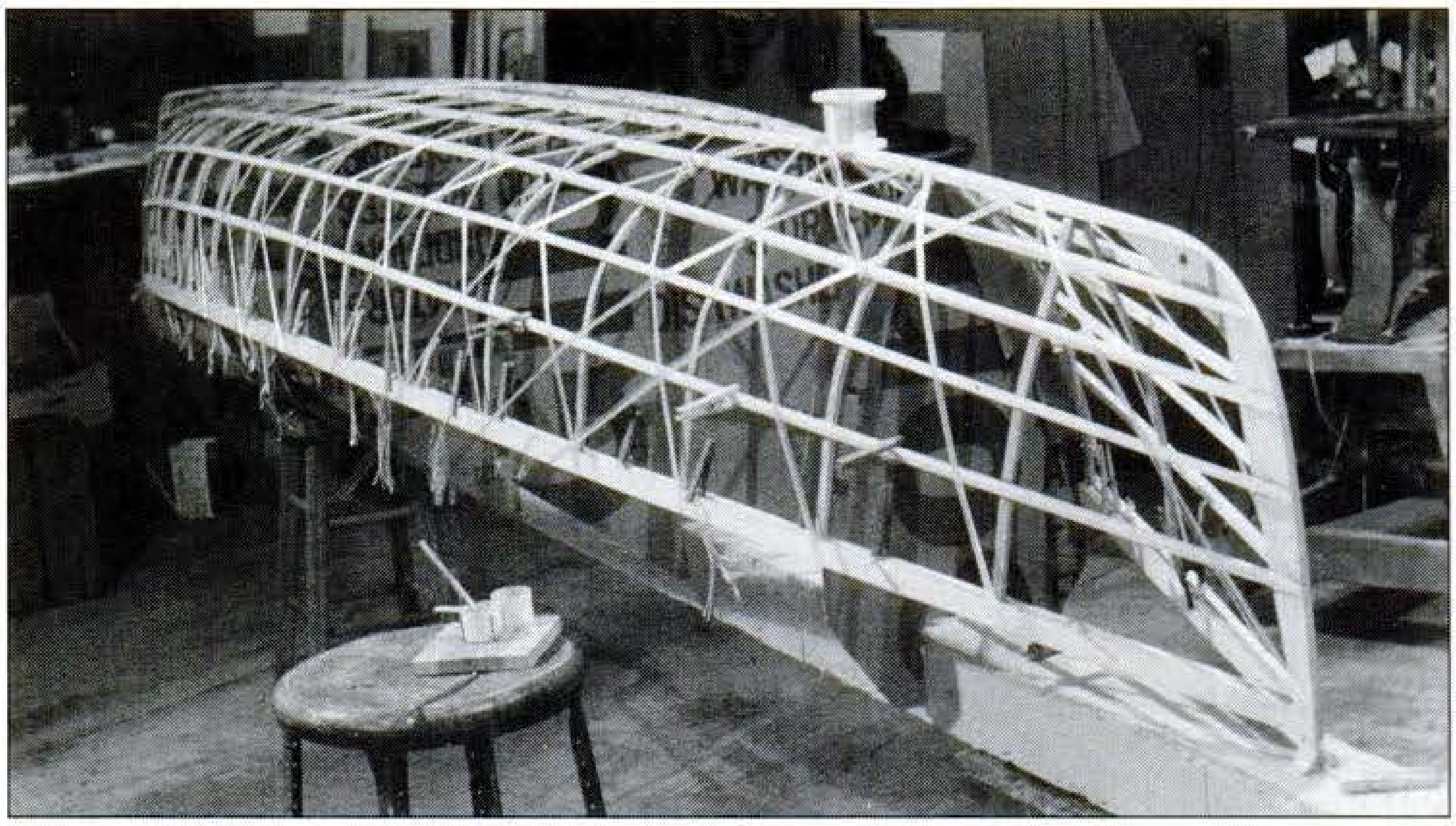
"Then I saw this mirror-finish Formica," he says, gesturing at the shiny surface of his particleboard worktable. As he talks, he spreads clear resin atop the previously applied gel coat, then unrolls a piece of fiberglass matting (see photos). "You can laminate up a boat section like this in an hour," Reluga says as he rolls resin across the fiberglass. "When it dries, this whole thing will pull right off the Formica, ready to go without sanding or painting," he adds.

To assemble the sections into a boat, Reluga places them into a jig. "The jig is very crude," he says. "You use the cheapest lumber and put it together fast." For the boat shown, he used five cross-braced frames—stations, in boat builders' argot—to hold the boat sections in the proper alignment (see drawing). After taping the joints on the outside, he applies fiberglass to the inside. A laminated wood gunwale provides all the stiffening needed.

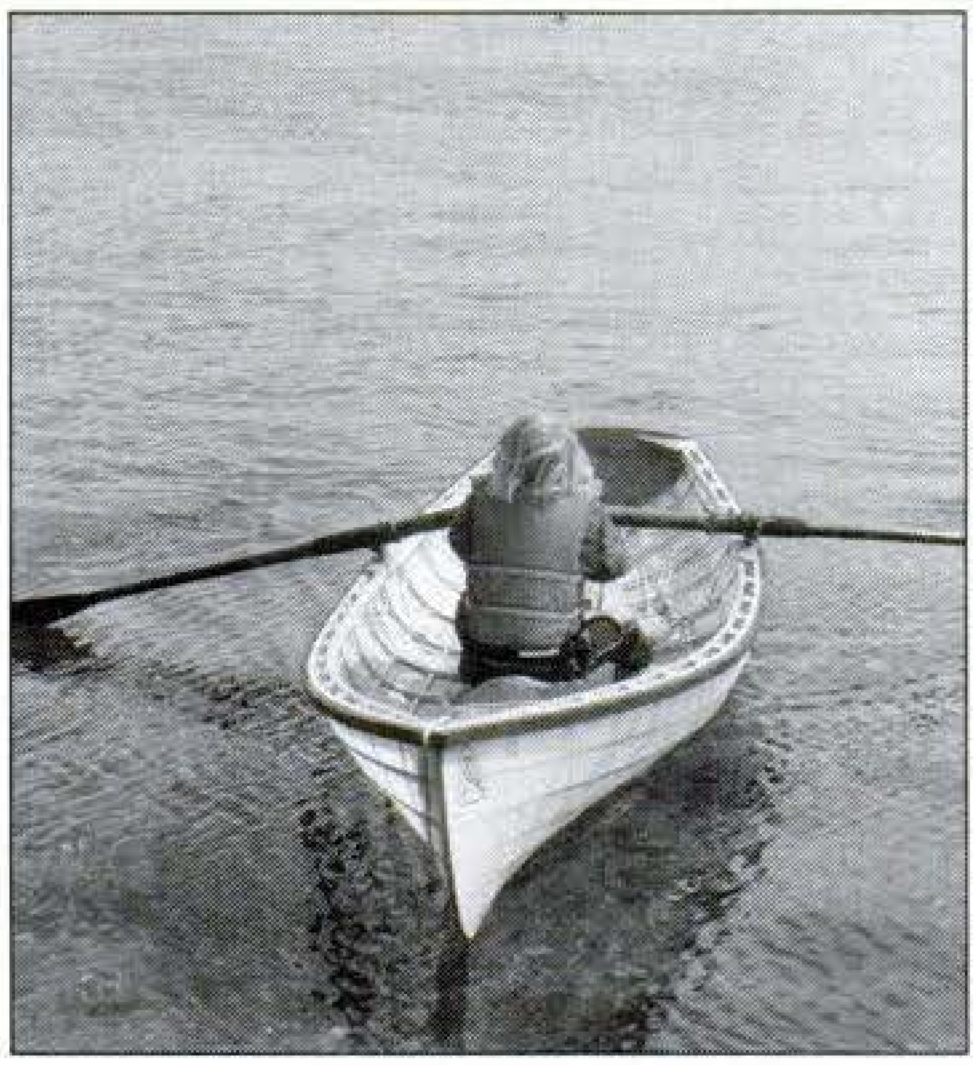
"I would unhesitatingly say it takes much less time to build a fiberglass boat than a plywood one," Reluga says. "It took me about 50 hours to build this boat, excluding mast and sails.

"And the method has more than speed to recommend it. You get superior results virtually impossible to duplicate in plywood," Reluga adds,

Continued



Corrugated-cardboard stations support the light canoe frame. Crisscrossed strips of aramid roving add strength so thin wood ribs can be used.



A child easily rows the 10-ft., 18-lb. Whitehall Jr. (right), designed by Platt Monfort to be stable in heavy chops. Snowshoe 14 (above) weighs 20 lbs.

gesturing at the bright-hulled skiff on its trailer. "This little skiff can withstand a lot of abuse."

The three-passenger boat, which cost Reluga about $200 to build, would cost about $2,000 to buy, he estimates.

From planes to canoes

"I wanted to design an ultralight aircraft," Platt Monfort says, explaining the roundabout way he developed the Kevlar-aramid-based boat-building technique he's dubbed Geodesic Airolite. "I built an eight-pound canoe just to test my theories of aircraft construction. I put it in the water, proved that it worked—then stood it in a corner of my workshop."

Three years later, as an afterthought, he brought the canoe along to an exhibition of aramid-based aviation designs. "The canoe was a hit," he says, "and people started asking for plans and kits."

According to Monfort, most home boat builders today make canoes by painstakingly edge-gluing thin strips of planking together to make a shell, then sandwiching the shell between layers of fiberglass and sanding it smooth. Others build up a laminate using super-thin strips of wood veneer bonded together with epoxy [PS, March '84]—an equally tedious process.

"For my canoes, I use a simple basketlike wood framework reinforced with aramid roving [straight, multi-fibered strands]," Monfort says. "I cover the whole works with a super-lightweight heat-shrink polyester, the kind used for airplane wings."

Monfort's method has four other unusual—and time-saving—features:

- The quick-construct building jig has hull supports cut from corrugated cardboard instead of plywood.
- The boat's ribs are so thin they can be water-soaked instead of steamed.
- The lengths of aramid are simply wrapped from gunwale to gunwale across the wood framework (ribs, keel, and longitudinal stringers)—no gluing or nailing is needed.
- The polyester skin is smoothed with a household iron, then finished with two coats of urethane varnish instead of multiple coats of airplane dope.

"These boats are so lightweight, they're easy to build. It's much less work to make one of these boats than by using any other method. When you have a 20-pound boat, there just isn't that much material to handle," Monfort says.

For example, the mayor of a city in Maine put together the 12-foot canoe kit. "He built it in three weeks—in his spare time—in his living room," Monfort says. "This is not a messy boat to build. In fact, a number of them have been made in living rooms."

Not only is the method simple, but the boats are much lighter than conventional canoes. One of Monfort's newest designs, the 10-foot Whitehall Jr., weighs just 18 pounds.

"I wanted to make a boat that's neat for kids—simple to build, lightweight, easy to handle—seaworthy, and cheap enough that you can afford to give it to the kid," Monfort says. "It's all that. But this boat also takes a hell of a load. We've had a 225-pounder aboard testing a heavy outrigger rowing rig with nine-foot oars."

New workshop materials

Monfort suggests at least one other use for his Geodesic Airolite construction method. "Suppose you need an aerodynamic shell for a high-speed bicycle—this would be ideal for that, or any other vehicle that needs a lightweight fairing," he says. And Henry Reluga sees many possibilities for fiberglass plank construction. "It's ideal for building shower stalls, durable outdoor furniture, poolside slides, and toboggans," he says. For projects with multiple curves he suggests using a reinforcing beam made by laminating fiberglass over a rope or piece of plastic tubing taped to the back of the object.

Reluga (102 Higley Rd., West Granby, Conn. 06090) provides project suggestions along with complete dinghy plans for $20.

Monfort (RFD 2, Box 1490, Wiscasset, Maine 04578) offers a data sheet on eight boats for $1. Complete plans cost abut $20; kits, $295.

Home boat builders tackle aluminum

Aluminum is both lightweight and durable, but welding it requires more sophisticated skills and equipment than does welding steel. "We have been amazed at the number of people experienced in aluminum," says Glen L. Whitt, president of Glen-L Marine Designs (9152 Rosecrans, Bellflower, Calif. 90706). "Our business is boat plans, but we don't put them out unless there's enough demand. The Double Eagle boat is our response to the many people who've asked for aluminum boat plans." Glen-L's new 23-foot craft can be built in plywood (plans and full-size patterns, $80) or aluminum ($90). "A good aluminum welder can put a boat together much faster than he can working with wood," Whitt adds.

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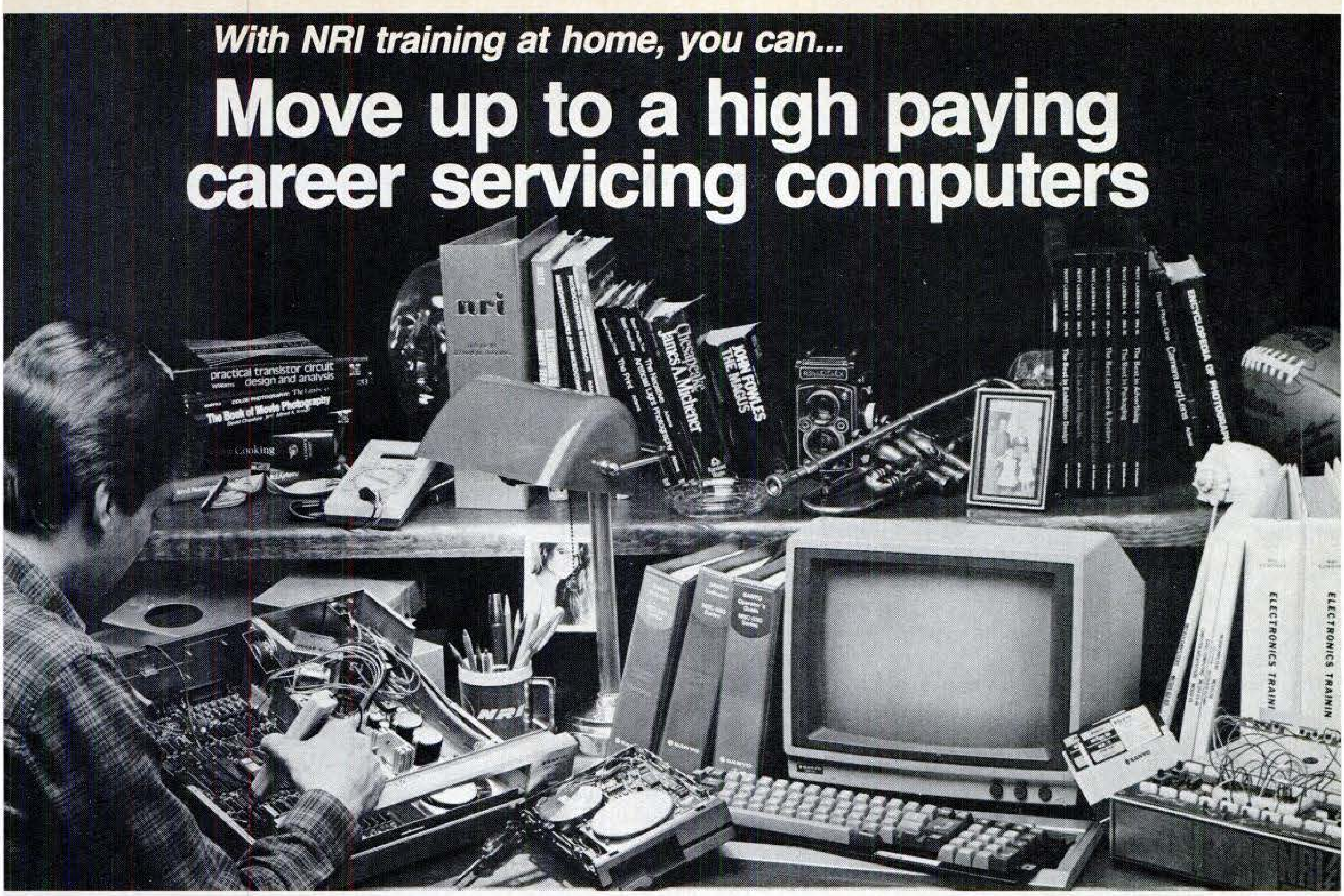
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Alternate-Energy Answers

By JAN F. KREIDER

Jan F. Kreider is a consulting engineer specializing in the design and economic analysis of solar-energy and energy-conservation systems. He is the author of several books on solar technology and a lecturer at the University of Colorado.

Channeling heat

Several years ago I added a sun room to my house. On sunny January days the room's temperature reaches almost 90 degrees F. How can I use this solar heat in the cold north side of the house other than just letting it drift north as it does now?

J. David Singer
Ann Arbor, Mich.

The best way to accomplish what you want is to install a fan controlled by an air-conditioning-type thermostat. A typical flow rate is four to six cubic feet per minute per square foot of glass in the sun room. If you reach 90 degrees F in your climate in January, apparently there is insufficient storage mass exposed to the sun. The addition of some water barrels or floor mass is advisable because elevated interior temperatures cause more heat loss during the day.

Geodesic-dome fireplace

I am building a 50-foot-diameter geodesic dome, which will be heated by a central Russian fireplace on the main floor. The fireplace will be mounted directly on an earth foundation resting on the earth basement floor. How can I control heat loss to the earth at large?

H. Vincent Diamond
Ambler, Pa.

My inclination would be to isolate the foundation from the surrounding earth if you have insulated vertically downward from the circumference of the dome. Your perimeter insulation will control basement heat loss, and a heat leak from the fireplace to the earth is not needed. In summer, the thermal break will have additional benefit because heat stored in the earth beneath your house will not be released into the basement all summer long.

Best water-heater element?

As an electrical contractor, I replace dozens of water-heater elements each year in 40-gallon tanks. What is the most energy-efficient type of element to use?

Jon R. Forsberg, Montauk, N.Y.

From the energy-consumption point of view, all electrical water-heater elements are essentially the same. They convert electricity to heat at nearly 100-percent efficiency. However, in addition to the question of consumption, one should also consider the question of demand control. The usual 4,500-kilowatt unit can increase an owner's demand charge versus a unit half the size. Of course, a unit half the size has half the recovery rate. This effect can be offset, to some extent, by using a larger tank for storage.

Evaporator cover?

What is the benefit of covering the evaporator of a heat pump with a transparent structure in winter? If I shade the same unit in summer, will the performance be improved?

Alex Templeman, Radford, Va.

The only gain in winter would be some moderation of outdoor air temperature by solar gain through the transparent structure. However, without the presence of components such as controls and storage, the benefit will be small because of the mismatch between solar availability and heat-pump operating time. The structure must be essentially open to satisfy heat-pump airflow requirements. Shading the condensing unit in summer has more promise and, given the small cost of doing so, is advisable as long as you don't impede the free flow of air.

Crushed-rock storage box

My new solar home will use crushed-rock storage. Is a vertical or horizontal airflow through storage better? Is there an optimum length for the storage box?

Peter Graham
Great Whale River, Que.

Both types of storage are satisfactory. The construction of a horizontal-flow unit requires more care because an air bypass over the top of the pebble bed can develop with time. This causes most air to short circuit around the rocks, and storage becomes ineffective. A rubber-foam seal, a layer of heavy plastic, or baffles extending down from the storage-container top can solve the problem. The length of the airflow path should be at least five feet. For vertical storage, heated air from the collectors should enter the top of storage, if possible.

Concrete vs. fiberglass pool

I'm planning to install a swimming pool in my backyard. Will a fiberglass pool retain heat better than a concrete one? Can the walls of the pool be insulated?

Ted Kazmar, Saugus, Calif.

There is little difference in heat-retention capability between fiberglass and concrete pools because the thermal resistance of both materials is very low. Pools can be insulated, but you should do an economic analysis considering the cost of insulating versus the cost of energy loss through the pool sides. Of course, most pool heat loss occurs from the exposed water surface, which should be covered when the pool is not in use.

Using excess heat

Having built a passive-solar greenhouse, I'm delighted with its performance. I have no heat source in it, and last year the lowest inside temperature was 56 degrees F. The heat is excessive during the summer, however, and I would like to put a solar preheater for my domestic-hot-water system behind the sloped glass. What do you think?

Barry S. Bidelspach
Hollidaysburg, Pa.

This is a fine way to use excess summer heat in your greenhouse. You should use a single-glazed collector about one square foot in area for each gallon of hot water needed per day. There will be some decrease in collector performance because sunlight must pass through two panes of glass instead of the usual one; use low-iron collector glass to help remedy this problem. In previous columns [March, July, and Nov. '84] I recommended books that give design and construction details for solar-water-heating systems. Before building the water-heater system, give some thought to what you will do with the collectors in winter, when excess heat is not a problem.

Do you have a question concerning use of an alternate energy such as solar, wind, water, or wood? Wondering about energy-conservation techniques for home heating or cooling? Every other month Jan Kreider answers selected questions from readers. Send yours to Energy Questions, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Queries can't be answered by mail.

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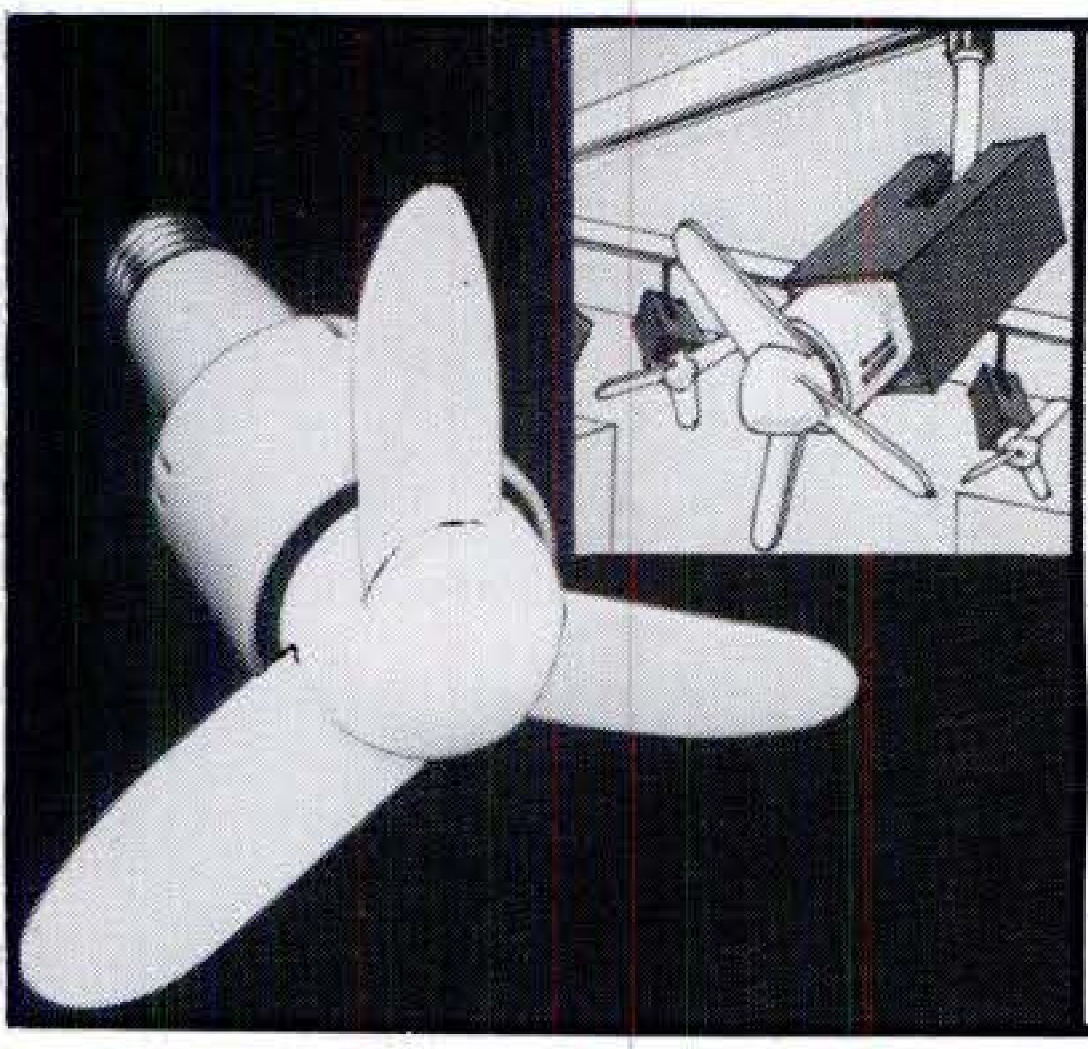

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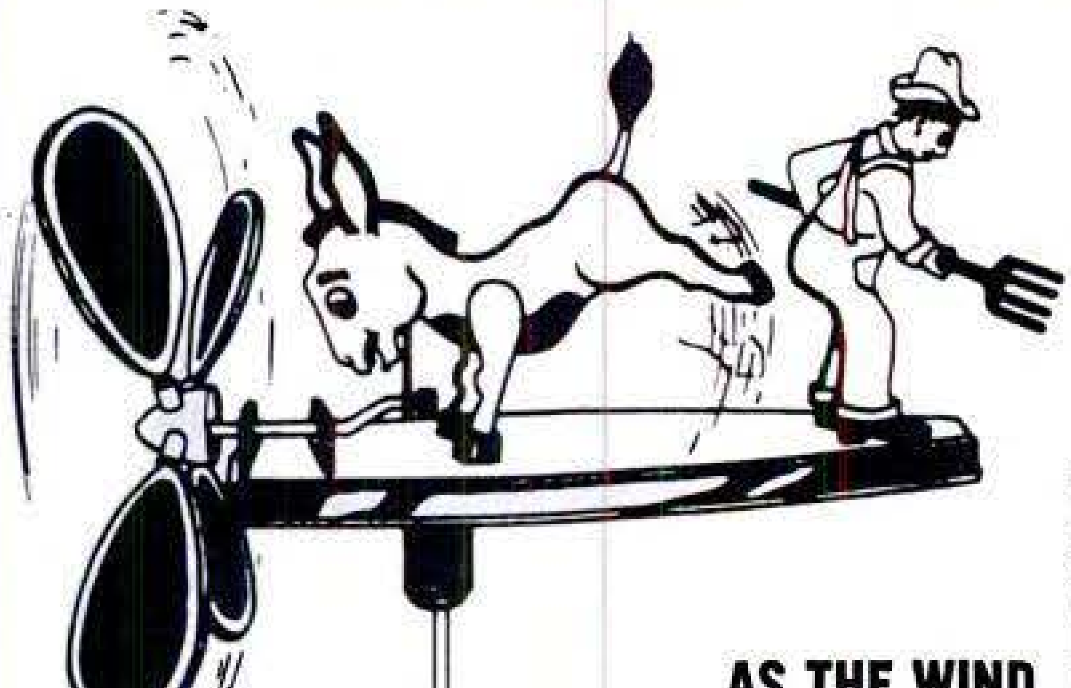

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SUPER SUPRA

Toyota's performance flagship sports a new 200-horsepower engine and an electronic suspension that provides big-car ride comfort or sports-car stiffness on demand.

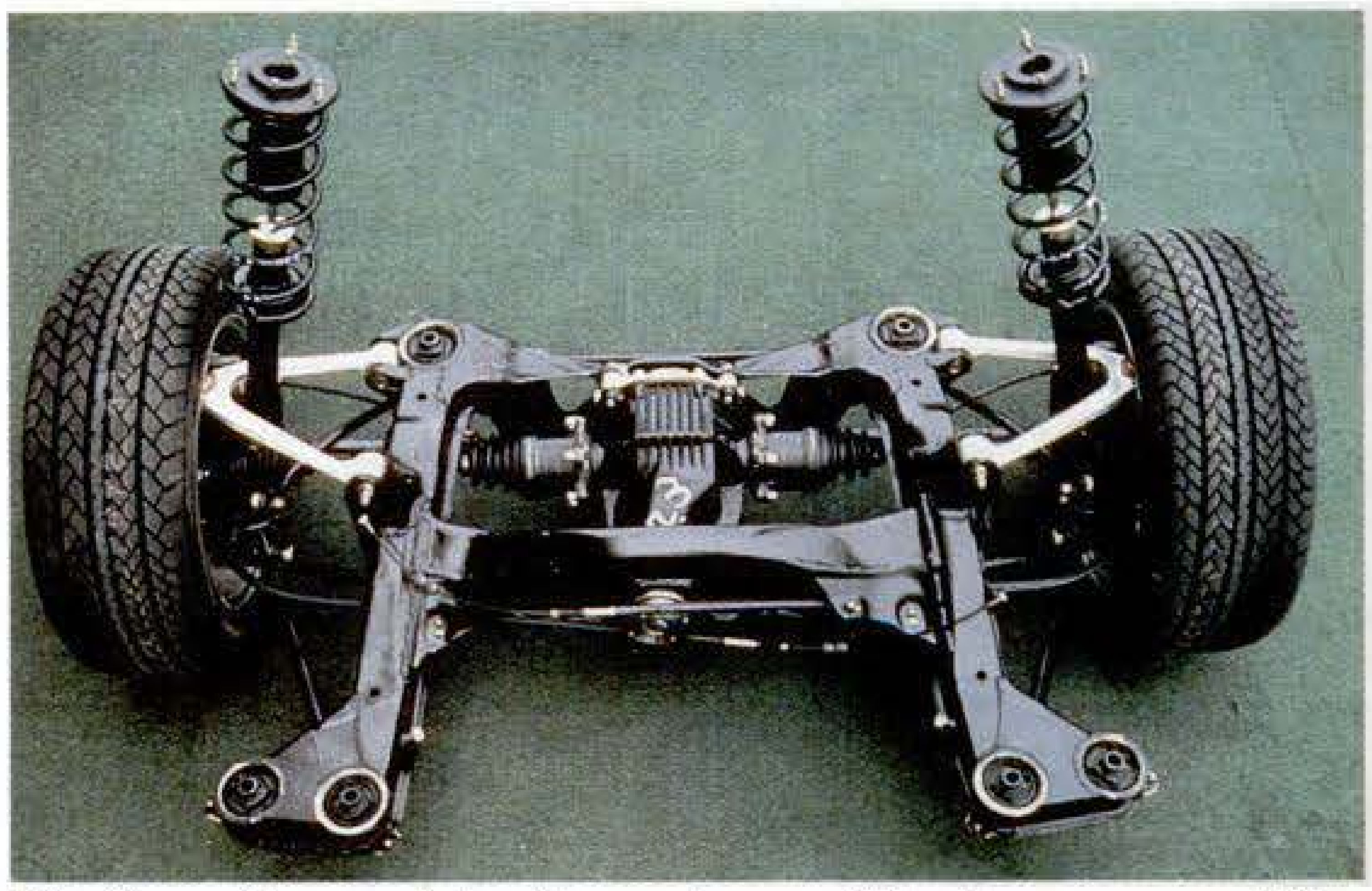
By JIM SCHEFTER

The speedometer is nudging 130 mph as the new Supra sports coupe reaches the end of the long straightaway beside the Japanese coast, and I have to brake for a tight spoon-shaped turn. Powered by a rumbling three-liter, 24-valve engine, the 1986½ Supra feels solid and stable charging down Toyota's Hamamatsu test track, as it does on the succeeding hairpin turns. The power steering responds nimbly on these quick left and right turns, while most of the vibration and road shocks are well dampened by the car's electronically modulated four-wheel double-wishbone suspension. Later, in a panic braking maneuver from 60 mph, the Supra's four-wheel disc brakes hold an even, straight line with no rear-end breakaway.

This year's swift Supra has a new look, along with a new price tag—estimated at $20,000. It's still a front-engine, rear-drive, two-plus-two sportster with the same 102-inch wheelbase, but the skin is smoother and more rounded than last year's, which gives the new model a drag coefficient of just 0.33. It's also a little shorter with an overall length of 182 inches. Most people consider the Supra's new shape to be a blend of Nissan's 300ZX and Mazda's RX-7, and even Akihiro Wada, chief engineer on the Supra project, admits the resemblance.

But the big changes, Wada adds, are underneath the new skin: "The major development points were to get a smooth and powerful engine, outstanding chassis performance, and the most comfort for the passenger and driver."

Wada chose a dual-overhead-cam, straight-six power plant that produces 200 hp at 6,000 rpm for the new Supra. The engine's high power is due, in part, to a new double-port fuel-injection system, Wada notes. Toyota's previous fuel-injection system put a single squirt of fuel into a cylinder. The new design has a pair of fuel channels backed by a single ball-valve outlet. Fuel flows into an expansion chamber, then is forced out equally through the two channels and into the cylinder's dual-intake ports. A computer changes the fuel metering and timing as the rpm varies, which provides trigger-quick acceleration (zero to 60 comes in 7.7 seconds, according to Toyota) and helps keep fuel mileage under control (city: 18 mpg, highway: 23 mpg).



The Supra's rear drive-line subassembly shows some of the technology behind the car's good ride. The shiny forged aluminum upper arms of the independent double-wishbone suspension save weight and provide a bit of give, while stiff lower arms supply stability. The suspension is mounted to a pressed-steel subframe to reduce vibration, which is further reduced by rubber joints with metal inserts. The 16-in. Goodyear VR tires were specially designed for the Supra.

The suspension (see caption) is electronically controlled to provide the damping needed for maximum comfort, Wada says. An interior switch allows the driver to select "Norm" or "Sport" settings. The system then monitors driving conditions to set the suspension to firm, medium, or soft.

For the driver and passenger in the two highly adjustable front bucket seats, Wada's comfort requirement has been well met. Unfortunately, the same cannot be said for rear-seat passengers, who had better be ready to assume the lotus position for lack of sufficient leg room. PS

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Fluid-change intervals

I am in the oil-changing business, and my customers often ask what intervals we recommend for fluid changes. Various lubricant, filter, and car manufacturers issue different and confusing sets of recommendations. What are your recommendations for service intervals to get maximum use with minimum repairs on the average family car?

David E. May,
Corpus Christi, Texas

I recommend changing engine oil every 3,000 to 4,000 miles; oil filter: every 7,000 to 8,000 miles; automatic transmission fluid and filter, manual-transmission lubricant, and differential lubricant: once a year or every 40,000 miles; brake fluid: every two years in hot weather, or every year in hot and cold conditions; radiator coolant: twice a year.

Bird eats flywheels

What would cause the flywheel to break on my 1979 Pontiac Sunbird? The car has 65,000 miles on it and has gone through four flywheels. The dealer has replaced all four, citing a defective part, incorrect installation, a warped transmission case, and a bad torque converter. An independent garage suggested the frame was misaligned during manufacturing. Any suggestions?

Dale Carlson, Centertown, Mo.

I believe that if the flywheel was corrected for run-out with reference to the transmission and torque converter in all planes, the breakage would stop. Several simple checks with a dial indicator can confirm this, but the transmission must be pulled back to do the job. I agree that the car could have been built somewhat out of alignment. If this is so, you should be able to use eccentric dowel pins or shims to line up the flywheel correctly.

Breaking in right

I just bought a new Toyota Camry, and the salesman told me I don't have to stay under 55 mph to break it in; he said the important thing to do is to vary speed a lot. I've always heard that to break in a new car you should drive gently at less than 55 mph. He also said I don't have to change the oil at 500 miles, nor do I have to retorque the head after the first few thousand miles. What is the best way to break in a new car?

David Lane, Ashland, Ore.

The salesman is right. Warm the engine up normally by accelerating moderately, then vary driving speeds between 50 and 60 mph for 2,000 miles or so to give everything time to wear in and fit. Leave the original oil in for as long as the owner's manual prescribes. The break-in oil is very good;

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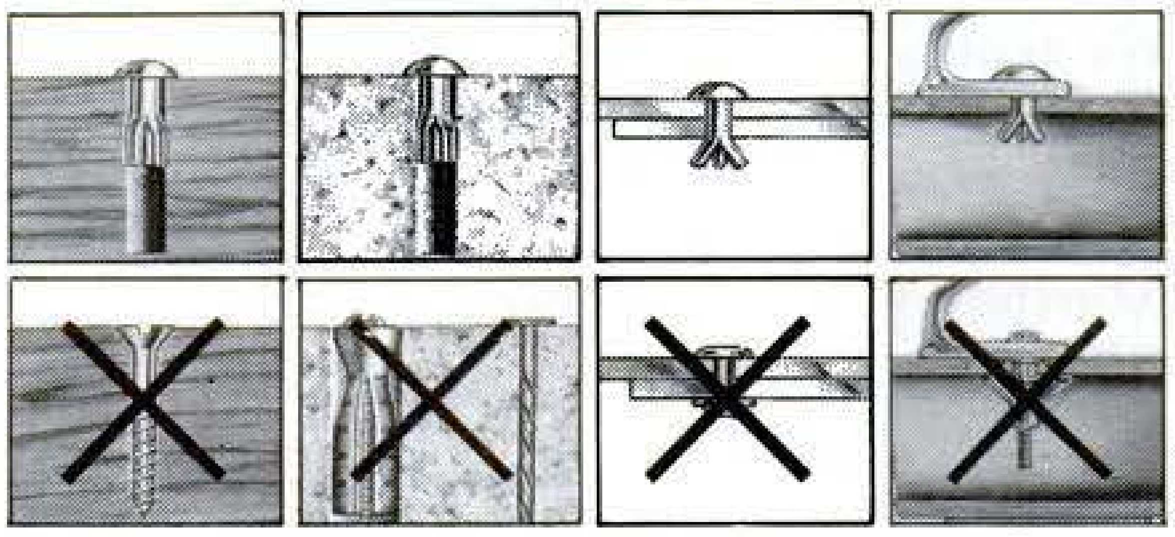

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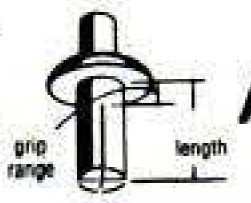

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don't second-guess the factory on this. Head retorquing has been pretty much engineered out of new cars unless the manual specifies it (this is rare). I suggest driving the car a couple of thousand miles before taking a long trip at steady speed; the engine needs 30 to 60 thermal cycles of short duration to wear the high spots off the mating part surfaces. Also, at first, stick to medium loads; don't start right off pulling a trailer in the mountains.

Hesitation blues

My problem is an annoying and potentially dangerous hesitation during acceleration in my 1984 Dodge Vista with the two-liter engine. The dealer has tried adjusting the carburetor and replacing some gaskets, but this never completely eliminates the hesitation.

Don G. Stephens, Tulsa, Okla.

Of all the cars with hesitation problems, about 80 percent are running too lean, and about 15 percent have ignition trouble; the rest have other problems or a combination of the above. I can only guess yours is running lean. Even if I could hit the problem on the head, you still might not be able to do anything to fix it for lack of special test equipment and tools. In today's battle between the car makers and the federal emissions and fuel-economy standards, the emphasis has landed on designing engines that run very lean. This leaves little room for error in setting them to the correct specifications. You will probably have to try other dealerships until you find one that understands your car and has the equipment to fix it.

The whistling carburetor

I have a 1982 Ford Fairmont with a four-cylinder engine equipped with a Holley two-barrel carburetor. Between 30 and 45 mph the carburetor squeals loudly when I step on the accelerator; above or below these speeds you can't hear the noise. Also, sometimes the engine dies at stoplights. A garage mechanic told me the only thing to do is change carburetors.

R. S. Bordner, Sunbury, Pa.

The Holley engineer I contacted suggests you try the following: Make sure all carburetor hold-down studs are tight. Check that the flange gasket isn't cracked or leaking and that it's the correct one (¼ inch thick with steel grommets). A failed or sticking EGR valve could be causing the noise. Make sure the EGR gasket isn't cracked or burned out. Finally, check the condition of the air-cleaner gasket, and be sure you have the correct one for your particular engine.

Perpetual camber

I recently discovered that there is no way to adjust front-wheel camber on my 1982 Subaru GL wagon. I feel that the incorrect camber is contributing to rapid wear on the outer edges of the front tires and the need for wheel balancing about every 5,000 miles. Are there any camber adjustment kits available?

Al Bateman, Shreveport, La.

Parts replacement and custom fitting of upper and lower suspension support points are the only options I know of.

Got a car problem? Send it to "Say, Smokey—," POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.

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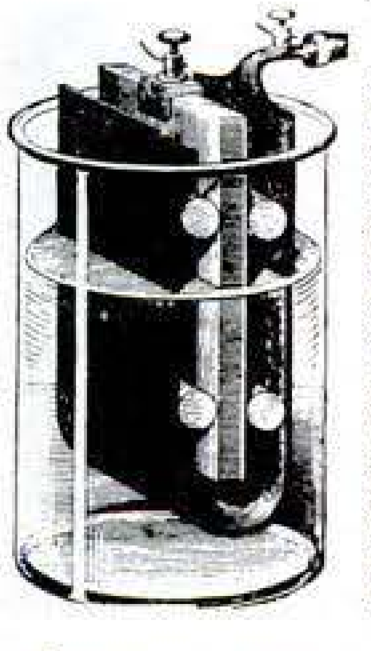

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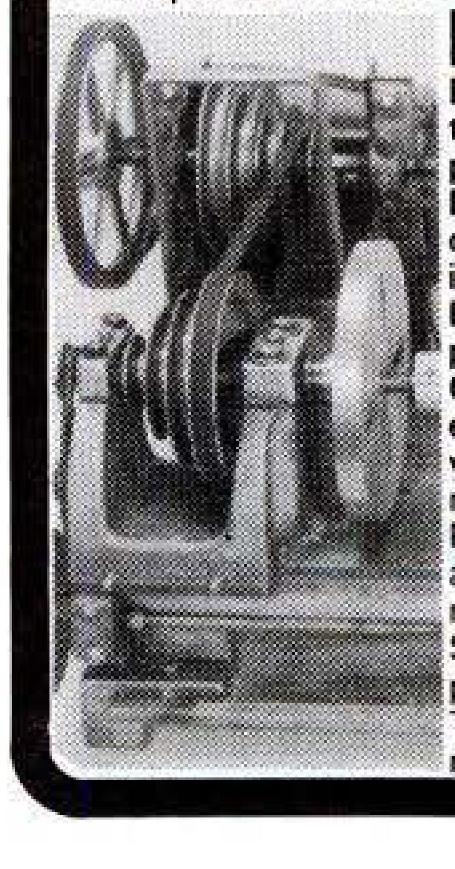

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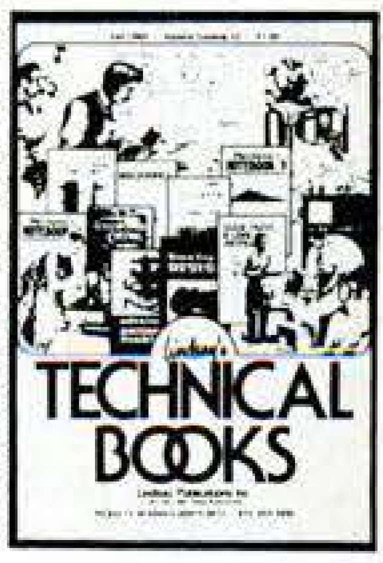

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Chevrolet Astro CL

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Plenty of power, lots of load capacity, and a quiet interior at highway speeds were aspects of this van that scored points with PS drivers. But a high floor, bouncy ride, and just-adequate fuel economy told us that Astro is different from Chrysler's mini-van.

By JACK KEEBLER

"Even when we showed them how, they didn't get the message." That's what a Chrysler advertisement for its mini-van says about Chevrolet Astro.

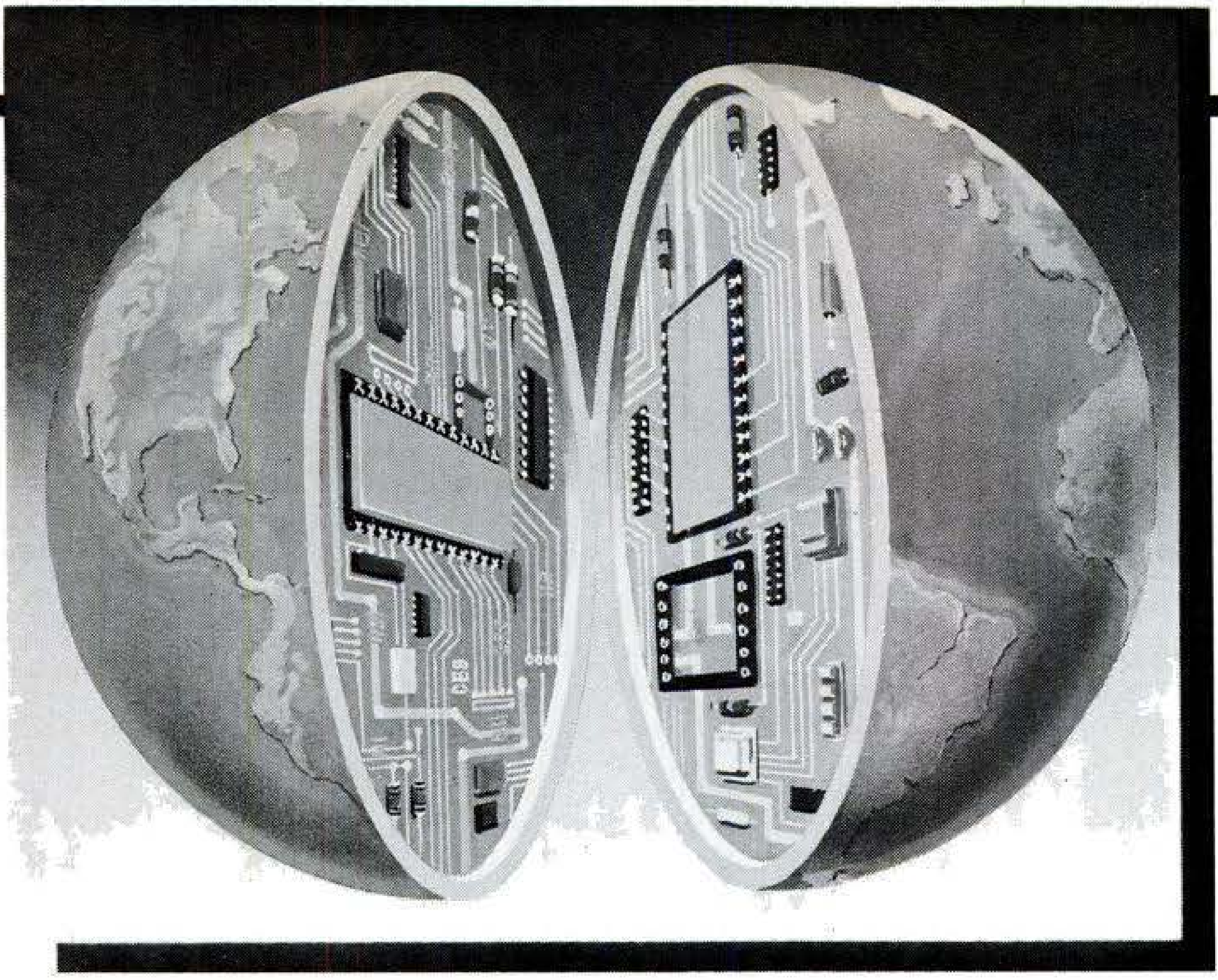
If Chrysler was giving lessons on building a new type of family wagon, General Motors was obviously playing hooky. Chrysler offers only four-cylinder engines and a three-speed automatic transmission; GM has a V6 and a four-speed automatic with a lockup torque converter. The Chrysler van is a front-drive; Chevy Astro is rear-drive. Chrysler offers a sedan-like ride and maneuverability; Astro rides and handles like a truck.

I found merging into fast-moving traffic a breeze with the Astro's 147-hp 4.3-liter V6. And at full throttle or during leisurely cruising, the four-speed automatic clicks off shifts smoothly and quietly. In fact, much of the credit for the van's interior quiet at high speeds should go to the overdrive fourth gear and lockup torque converter, which keep engine revs low. The Astro averaged 17.9 mpg for the 5,000-mile test period. A long highway trip netted 18.9 mpg, and some commuting in stop-and-go traffic earned a low of 16.4 mpg.

I found that the Astro's front-engine, rear-drive setup meant better grade climbing with a load but poor traction when the interior is lightly loaded or empty. Another negative aspect of rear drive is extra height. The Astro is 71.7 inches tall; the Chrysler van, 64.2 inches. Although many drivers enjoyed the lofty vantage from the seat cushion, climbing into the buckets is awkward, especially for small adults or children. And check the height of your garage door: The Astro wouldn't fit through mine.

Quiet and comfortable on smooth highways, the Astro was a different vehicle when the going got slow and rough. Over bad roads it bounded along like a kangaroo, and the interior boomed with the jounce and rebound of its massive suspension hardware. The heavy-duty suspension and boxy interior provide good load capacity. With the rear seats unbolted, Astro handles 183.6 cubic feet of cargo; the front-drive Chrysler van holds only 133.

Astro's poor ride quality and lack of maneuverability will probably scare off drivers of older sedans who are pondering a switch to a mini-van. But for the buyer who needs them, Astro offers a 5,000-pound trailer-towing capacity (Chrysler mini-vans provide only 2,000 pounds of towing capacity), V6-engine muscle, and a heavy-duty truck suspension in a slightly smaller, more fuel-efficient van. PS



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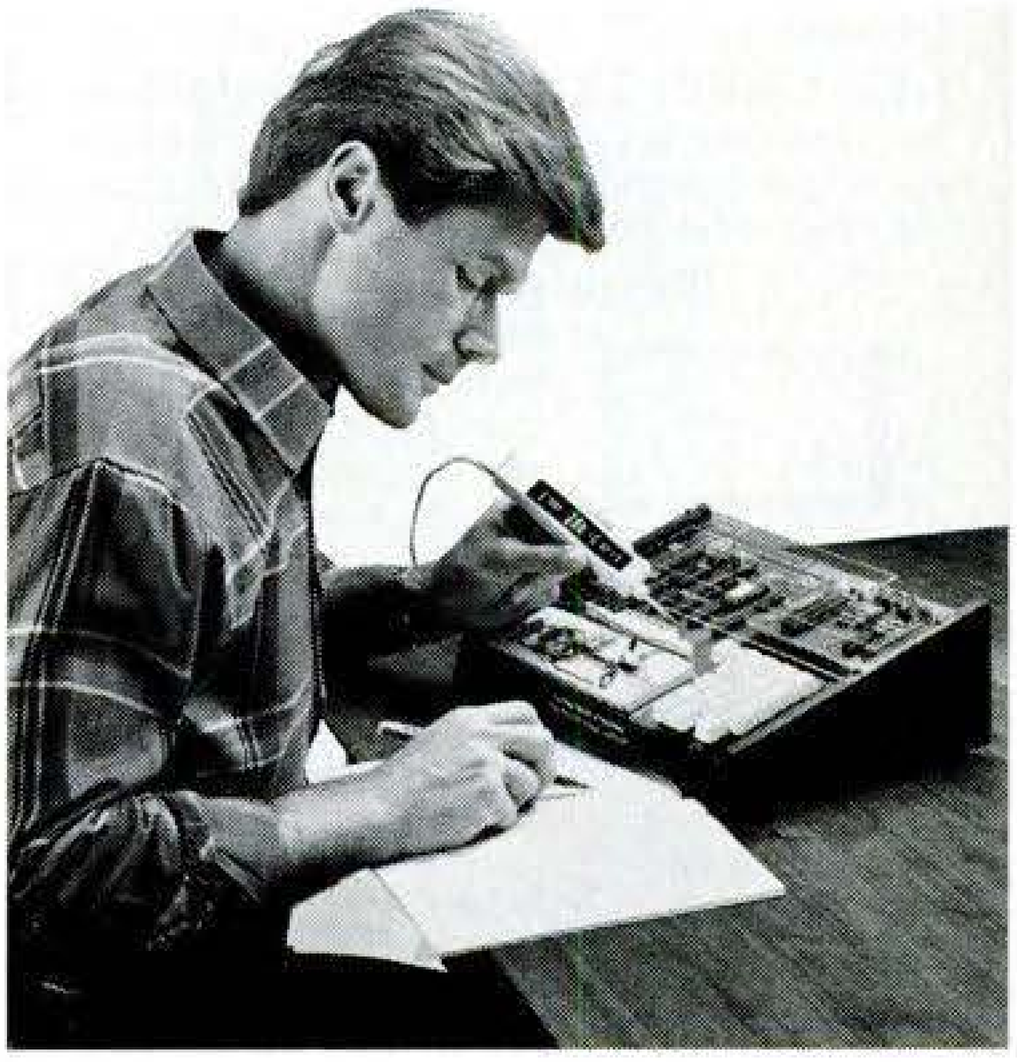

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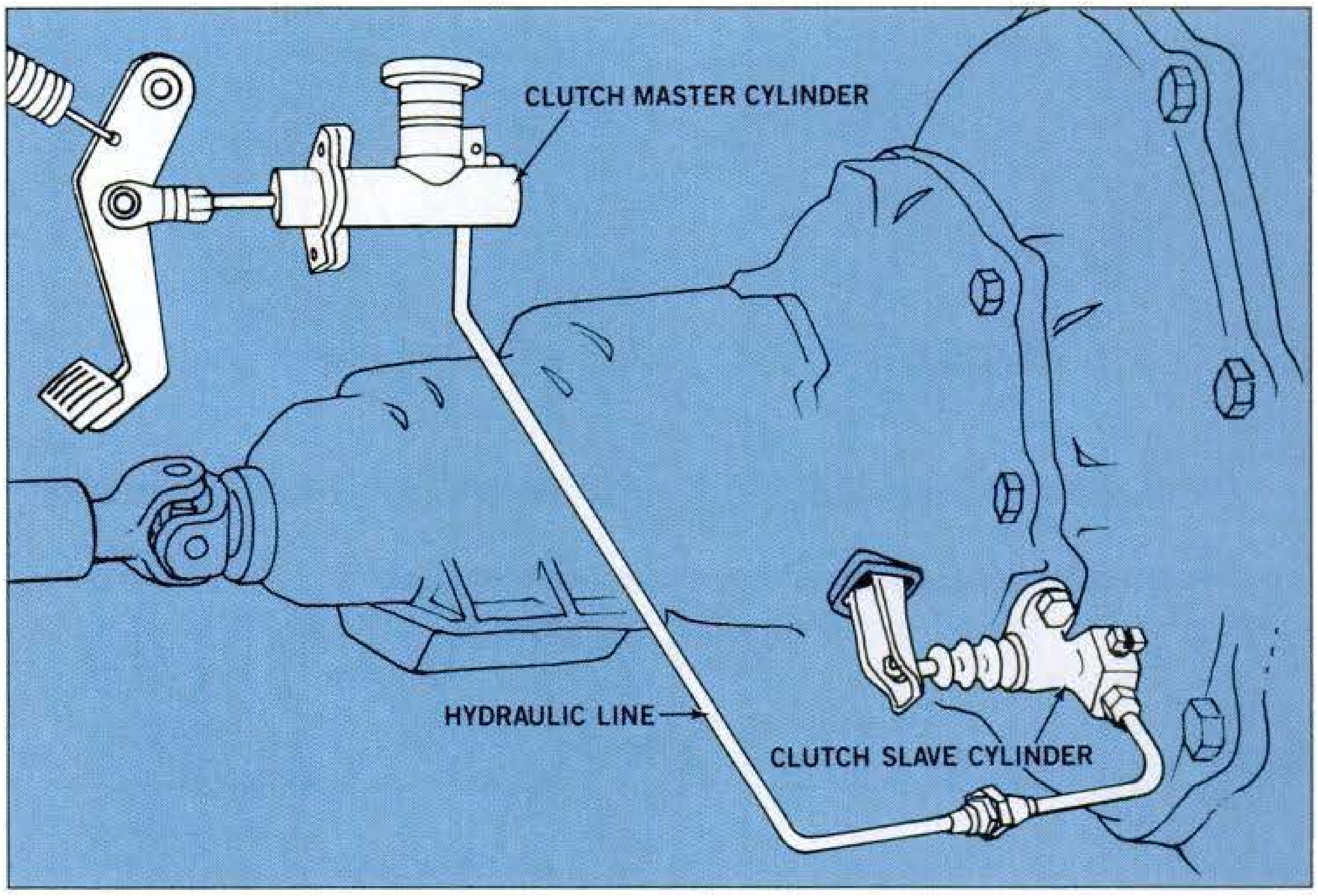
Taking Care of Your Car

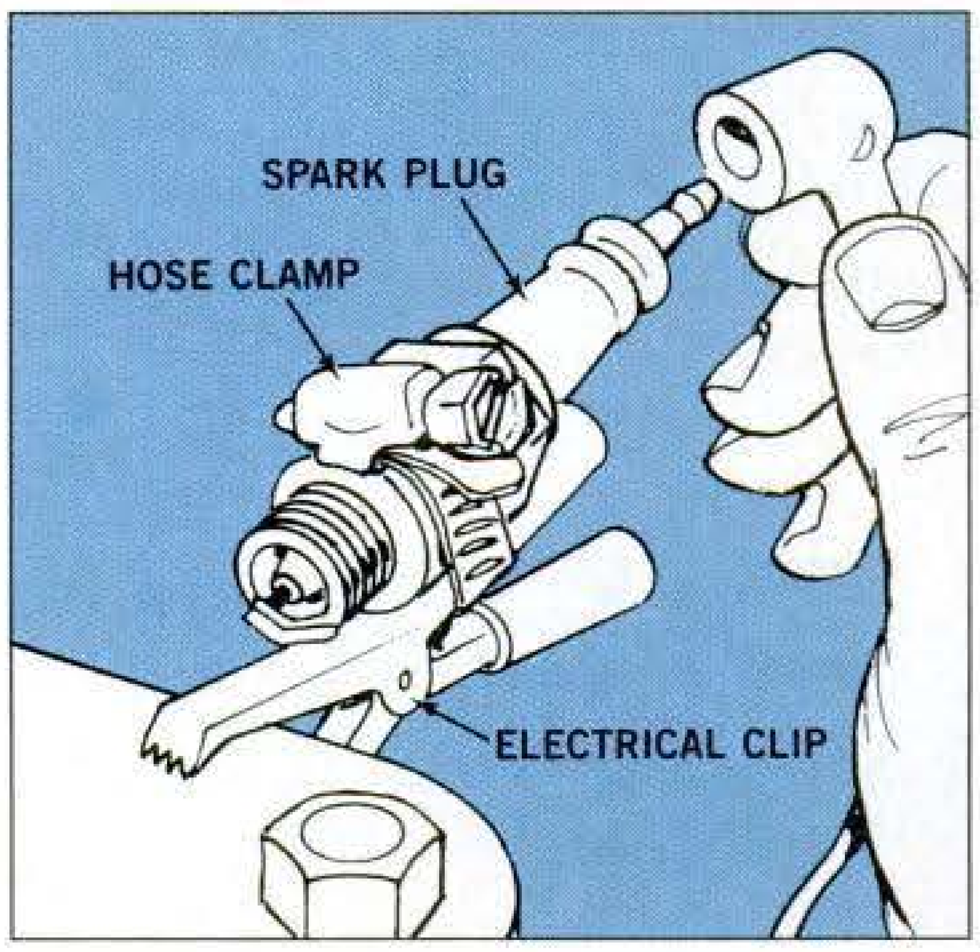
By STEVE MERCALDO

Got a useful car tip? Send it (with Social Security No.) to Car Care, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. We'll pay $50 if we use it. If two or more readers send the same tip, payment goes to the one with earliest postmark. No tips can be returned.



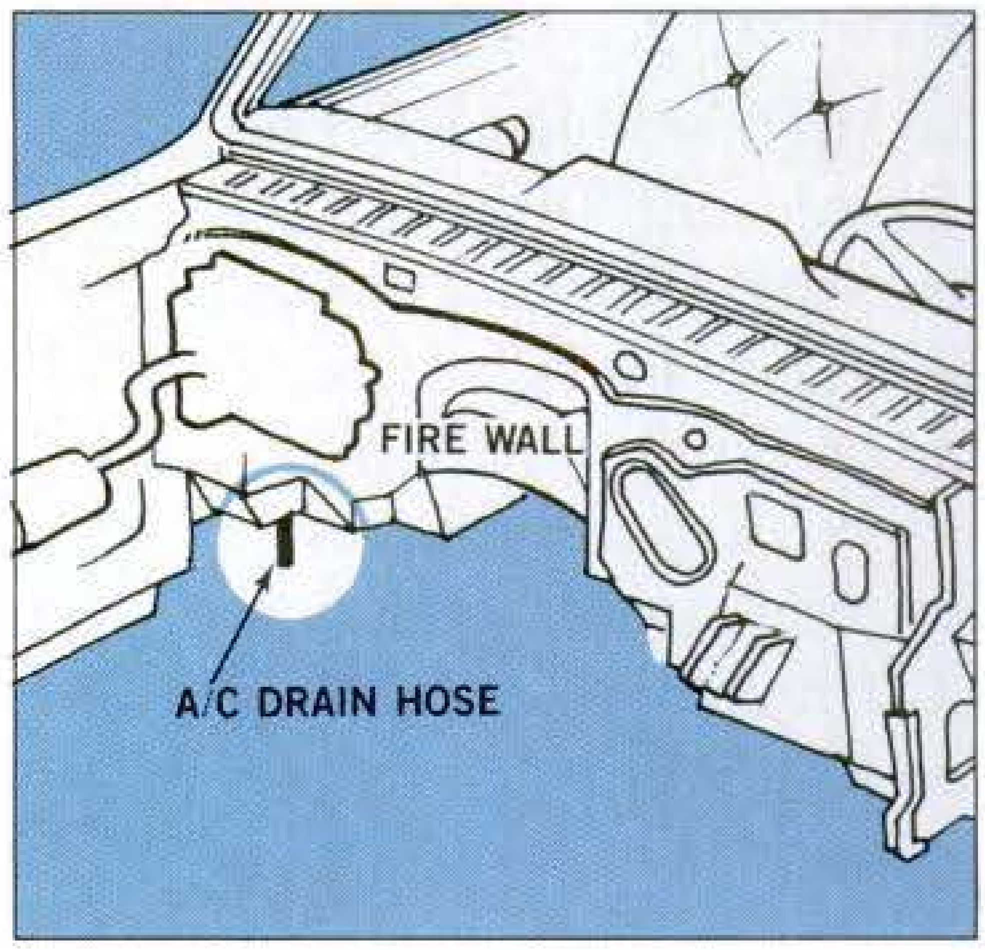
Shift grind

When you shift gears, does your transmission grind? If your car has a hydraulic clutch linkage, air in the line may be fouling a clean shift. To bleed the system, top off the clutch master cylinder and check for leaks. Next, slip a length of vacuum hose over the slave cylinder bleeder screw. Open the bleed screw a half turn. Place the other end of the hose in a container and have a helper pump the pedal until no air escapes. While the clutch is being held down, tighten the screw. Remember to check and refill the clutch master cylinder with the proper hydraulic fluid during and after the process.



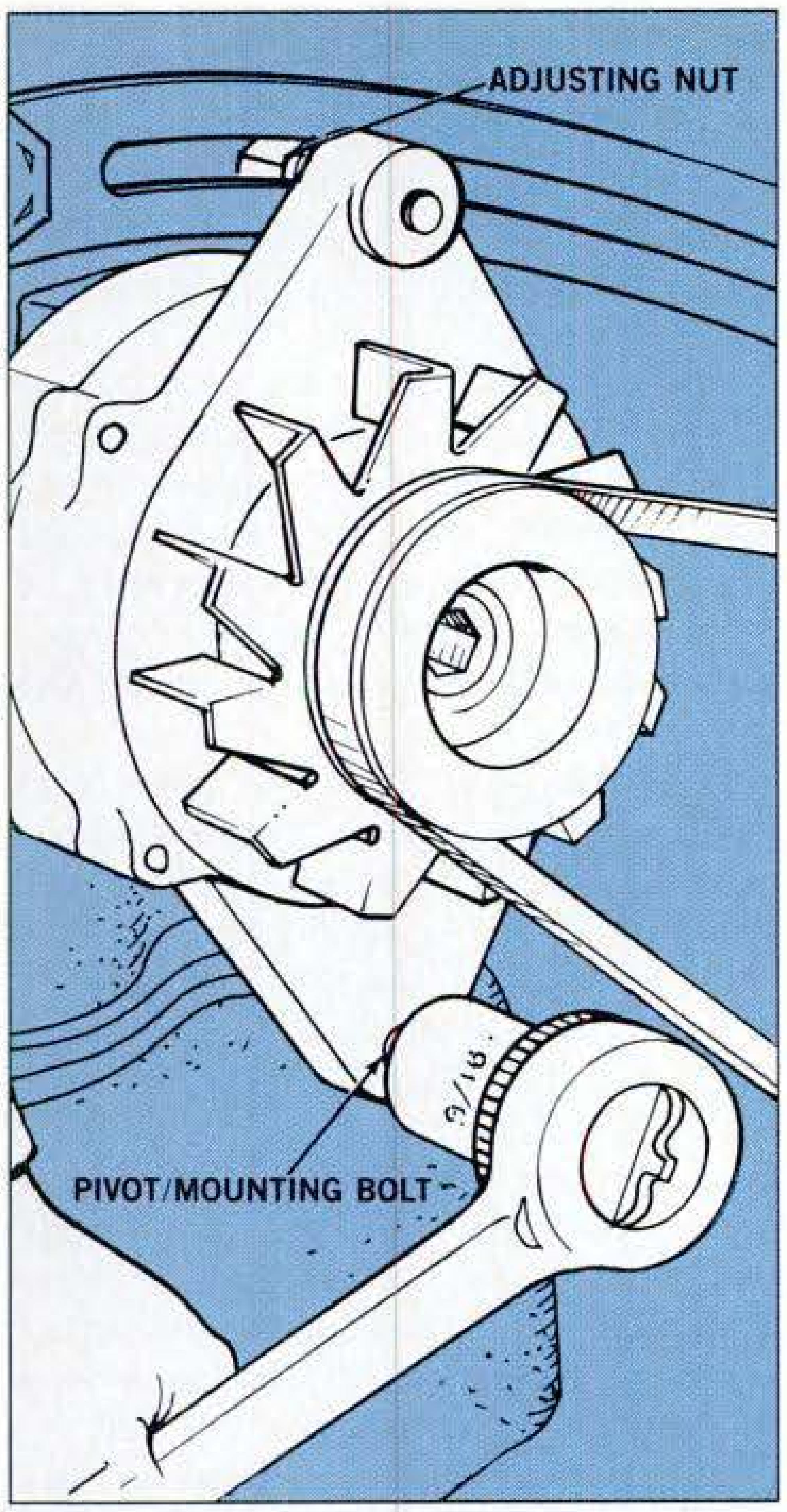
Spark-test tip

Ever been zapped when testing your engine for spark? If the spark plug could hold itself on a grounded surface, test results would be less shocking. Try this: Slip a hose clamp around an electrical clip and the waist of a good plug. This not only protects you but also protects the ignition system from damaging voltage surges.



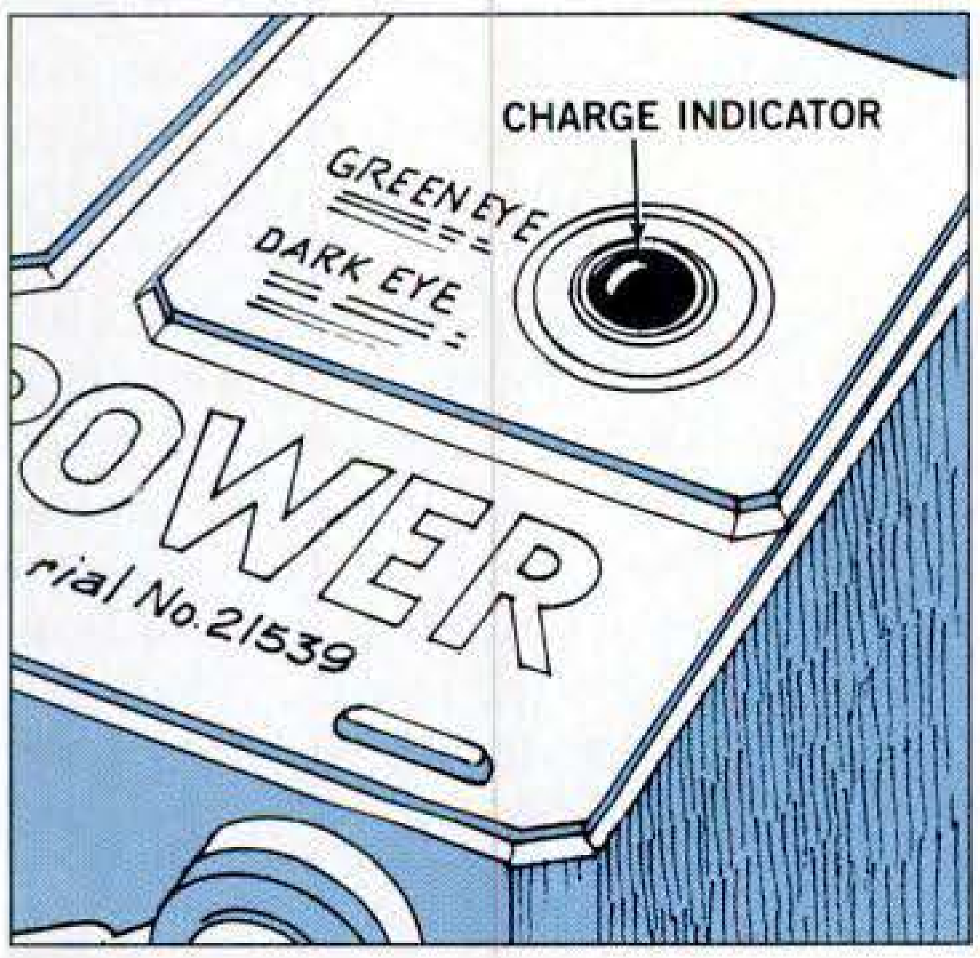
Musty-smell fix

Carpet on the passenger side that stays wet and has a musty odor may indicate a clogged A/C drain valve or a broken drain hose. The drain allows water to escape from the evaporator housing. If it's faulty, water soaks the carpeting. A probe may clear the drain hose at the bottom of the fire wall. If not, replace the valve.



Strong-arm warning

Don't try to muscle a belt-driven component that refuses to move after the adjusting nut has been loosened. Using a large pry bar and excessive force can permanently damage an alternator, air pump, or power steering unit. Locate and loosen the component's pivot mounting bolt.



Battery warning

Maintenance-free batteries now come equipped with a built-in charge indicator. The indicator can appear green, almost black, or clear. Do not attempt to recharge or jump-start a battery when the indictor is clear. This generally means the battery is low on water and filled with hydrogen gas. A spark could cause an explosion.

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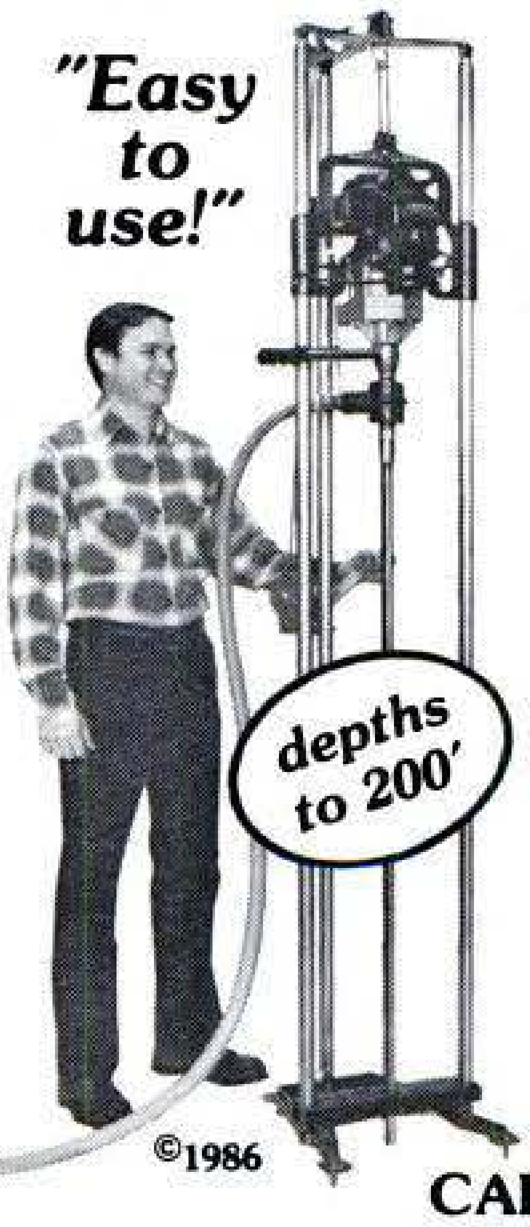
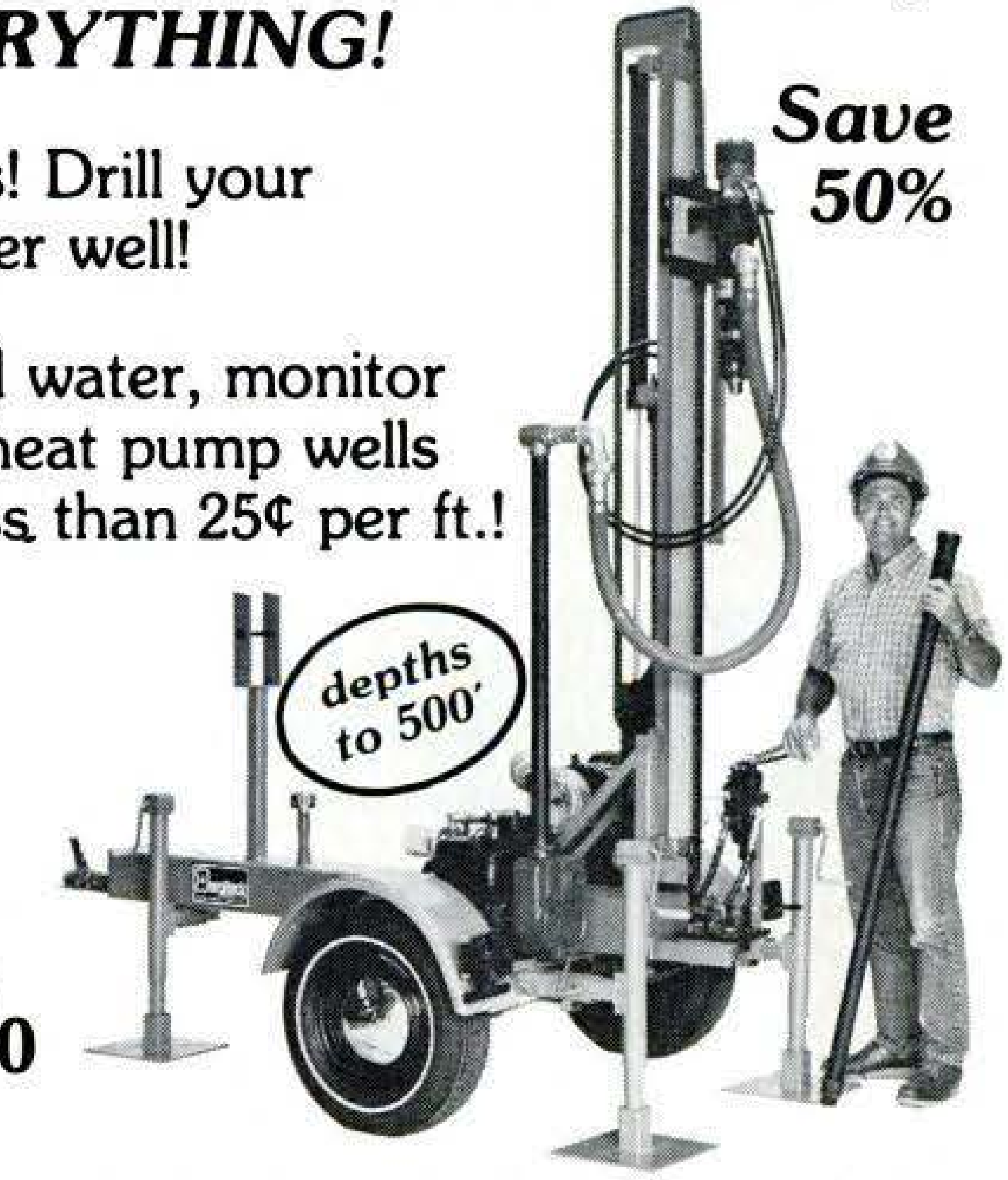
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[Continued from page 76]

is radiating long-wave infrared energy to that window. So are the warm walls, floors, and furniture. Glass is opaque to infrared wavelengths, so the window absorbs and reradiates that heat. Much of it ends up outside.

Double- and triple-glazed windows introduce air spaces that reduce heat loss through conduction and convection. But they do not reduce radiant-heat transfer. Low-emissivity windows do. Emissivity refers to the heat-emitting (or radiating) propensity of a surface. The emissivity number compares a given surface with that of a perfect radiator, called a blackbody (emissivity of 1). Ordinary window glass has an emissivity of 0.84, meaning it absorbs and emits 84 percent of the radiant heat. But put a low-emissivity coating on that glass, and the emissivity drops to between 0.05 and 0.40. That means it will *reflect* somewhere between 95 and 60 percent of the radiant heat. Thus, low-emissivity windows can reduce your heating load by reflecting heat from people and interior surfaces. They also can reduce your cooling load: In summer they reflect outside heat radiated by driveways, sidewalks, and buildings.

Low-emissivity glazings are spectrally selective: Although they reflect most of the long-wave infrared radiation, they transmit most of the visible light, and unless engineered not to, they transmit a good bit of solar energy. On the other hand, low-emissivity glazings reflect most of the sun's ultraviolet rays, the wavelengths responsible for fabric fading.

The coating that delivers this special blend of benefits is an atoms-thin layer of metal or metal oxide. The first such product, Southwall Technology's Heat Mirror film, was an outgrowth of research sponsored by the Department of Energy at the Massachusetts Institute of Technology. Soon after Heat Mirror was introduced, Guardian Industries brought out Low-E glass [PS, April '82]. Both glazings, and now many others, are coated using a technique called sputtering.

How it's done

In a large vacuum chamber in Guardian's plant in Corsicana, Texas, sheets of glass are coated with a layer of silver surrounded by two layers of zinc oxide. "The workhorse of the layer system is silver," explains Russell Huffer, Guardian's manufacturing manager. The silver reflects infrared radiation. The zinc oxide protects the silver and enhances visible transmission ["Invisible Insulation," PS, Aug. '83]. In the vacuum chamber, silver is deposited on glass an atom at a time by bombarding a silver target with ionized argon gas. "The positive argon atoms accelerate toward the silver, going two to three thousand miles per hour," explains Huffer. "When an argon atom hits the target, it knocks loose an atom of silver. The silver atoms fly out and coat everything—including the glass."

Sputtered coatings have emissivities in the 0.05-to-0.15 range (they reflect 95 to 85 percent of the radiant heat). But they are sensitive to moisture and abrasion. Thus, they can only be used in sealed double- or triple-glazed windows with the coating facing the air space.

Now sputtered products have competition: a low-emissivity glass whose coating is said to be as tough as the glass itself. It is called pyrolytic low-emissivity glass; the coating, usually a tin oxide, is applied to the glass while it is hot. It is, in effect, baked in.

Pyrolytic low-emissivity glass can be used as single-pane windows and storm panels, though it is most commonly used now in sealed double-glazed windows. But pyrolytic glasses have higher emissivities—generally in the 0.3-to-0.4 range—meaning they do not reflect as much radiant heat as the sputter-coated type. (Sentinel Agencies imports a pyrolytic low-emissivity glass from Europe that has an emissivity of 0.15, almost what the sputtered coatings claim.)

Total performance

"If you compare the sputtered with the pyrolytic, the bang for the buck is just not the same," Guardian's Huffer says. Though their emissivities differ, their prices are similar. Advertising often makes no distinction between the types, and product literature doesn't always include the emissivity of the glazing.

However, manufacturers do publish the U-value of windows, an even better indicator of their thermal performance. Although the emissivity indicates the heat flow via radiation, the U-value is a measure of total heat flow (in Btu/hour/square foot/degree F). The lower the U-value, the less readily the window transfers heat via conduction, convection, and radiation. Emissivity affects the U-value, but so does the thickness of the glass, and even more, the thickness of the air space.

But even the U-value does not tell the whole performance story. "You have to consider the solar transmittance as well," advises LBL's Selkowitz. The table lists the direct solar transmission of all the windows described, and gives another value, called the shading coefficient. The lower the shading coefficient, the less heat, direct and indirect, the window lets in.

Low-emissivity windows for the Sunbelt have lower solar transmission and shading coefficients because they use one pane of tinted glass.

High-transmission film

But in northern climates, solar gain can be a boon in winter, and low-emissivity glazings let in less sunlight than does standard glass. SunGain, 3M's high-transmission film, on the other hand, transmits more solar energy and more visible light than does standard glass. "For south glazing, where solar gain is important, high-transmission windows might be the best bet," Selkowitz advises.

Cost and savings

Double-glazed low-emissivity windows sell for about 10 to 15 percent more than standard double-glazed windows of comparable quality. Triple- and quad-glazed windows that use plastic films may be even higher.

How much they save depends on many variables. Andersen Corp. ran a computer analysis of 29 cities, comparing (among other things) the energy cost of its standard double-pane windows with its High-Performance (sputter-coated low-emissivity) double windows. The study assumed a 1,720 square-foot house with 152 square feet of glass evenly distributed on four sides.

In one scenario in Pittsburgh, Pa., standard double windows would account for $161 of the annual fuel cost, the study showed; with High-Performance windows that would drop to $82. In Denver, Colo., one scenario indicated that standard double windows would entail a $143 net energy loss; High-Performance windows, only $68.

In Tampa, Fla., Andersen's High-Performance Sun windows would entail an $88 annual energy penalty with gas heat and electric cooling, compared with $251 for double panes, and $359 for aluminum-frame single-glazed windows. With electric heat and cooling, double windows would entail a whopping $456 energy penalty, compared with $105 for High-Performance Sun windows.

It boils down to this: The more heating and cooling you need, the more window area you have, and the more expensive your fuel, the more you'll save by buying better windows. And the more important solar gain, the more you should consider transmission.

When you go window shopping, remember that the sash and frame also influence window performance. If it's low-emissivity windows you're after, check the appearance. These windows have a slight tint, more pronounced in some than in others. PS

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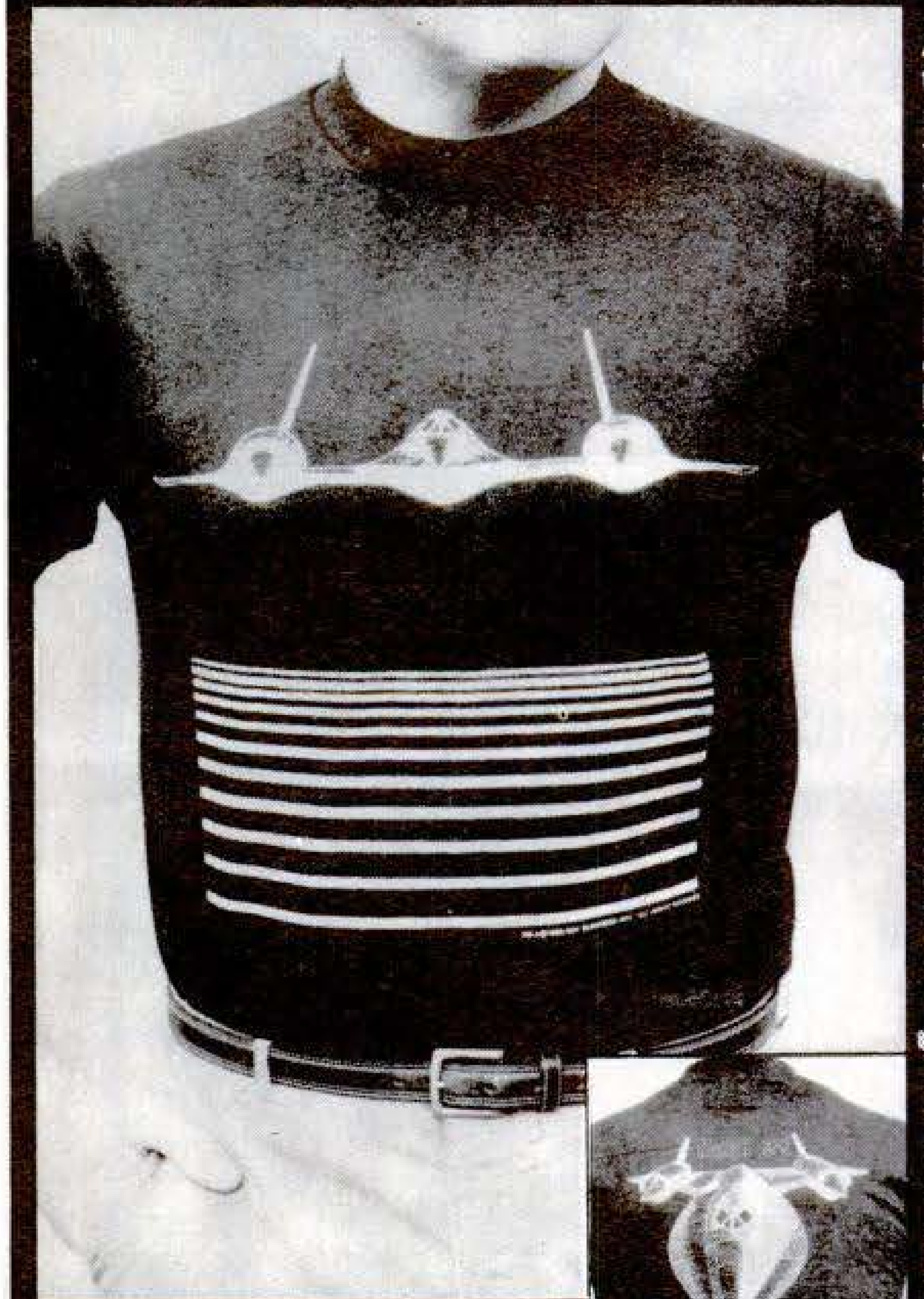

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[Continued from page 85]

nology, there are interesting and sometimes extraordinary claims about the tools that are emerging," says Davis. "You have to make your own judgment often by trying these programs to see what they can and cannot do for you."

Expert tester

One person who has been trying is Dr. Spencer Swinton, research psychologist for the Educational Testing Service, in Princeton, N.J. The company writes the Scholastic Aptitude Test given to high-school students for college acceptance.

"The idea is to have an expert system give the test," Swinton told me. "How well the student performs determines the next level of questions."

If it works, the six-hour exam could be cut to an hour or so. But so far there have been difficulties. "I've been working on the math portion of the test," said Swinton. "But there are simply far too many possible answers to any one problem."

In his trials, Swinton typed random answers to each question. Despite his totally illogical responses, the system drew definite conclusions about how well he understood the subject. "That simply won't do," he said.

Will he keep trying? Of course, and so will many others. Software and hardware manufacturers are just now starting to use expert-system shells to develop libraries of knowledge modules on a vast range of subjects for education, business, and home use. Analysts predict that it may take as long as three years before we'll see results, but the wait will be worth it.

"We humans think of ourselves as being rather good at reasoning, but at best we perform about a hundred logical inferences a second," says Feigenbaum. "We're talking about future expert systems that will be doing ten million inferences a second. What will it be like to put a hundred years of thought in every decision? Knowledge is power." PS

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Butcher-block table

[Continued from page 93]

partially level the top. This will give you a flat surface to ride against the fence as you joint the edges smooth and flush. Now glue on the front and rear aprons.

Set the completed butcher-block assembly up on its side to let the glue dry. Then joint the sides, and trim the bottom on the table saw. Drill 1¼-inch-diameter holes in the apron sides, and insert tapered circular maple plugs.

Sanding and finishing

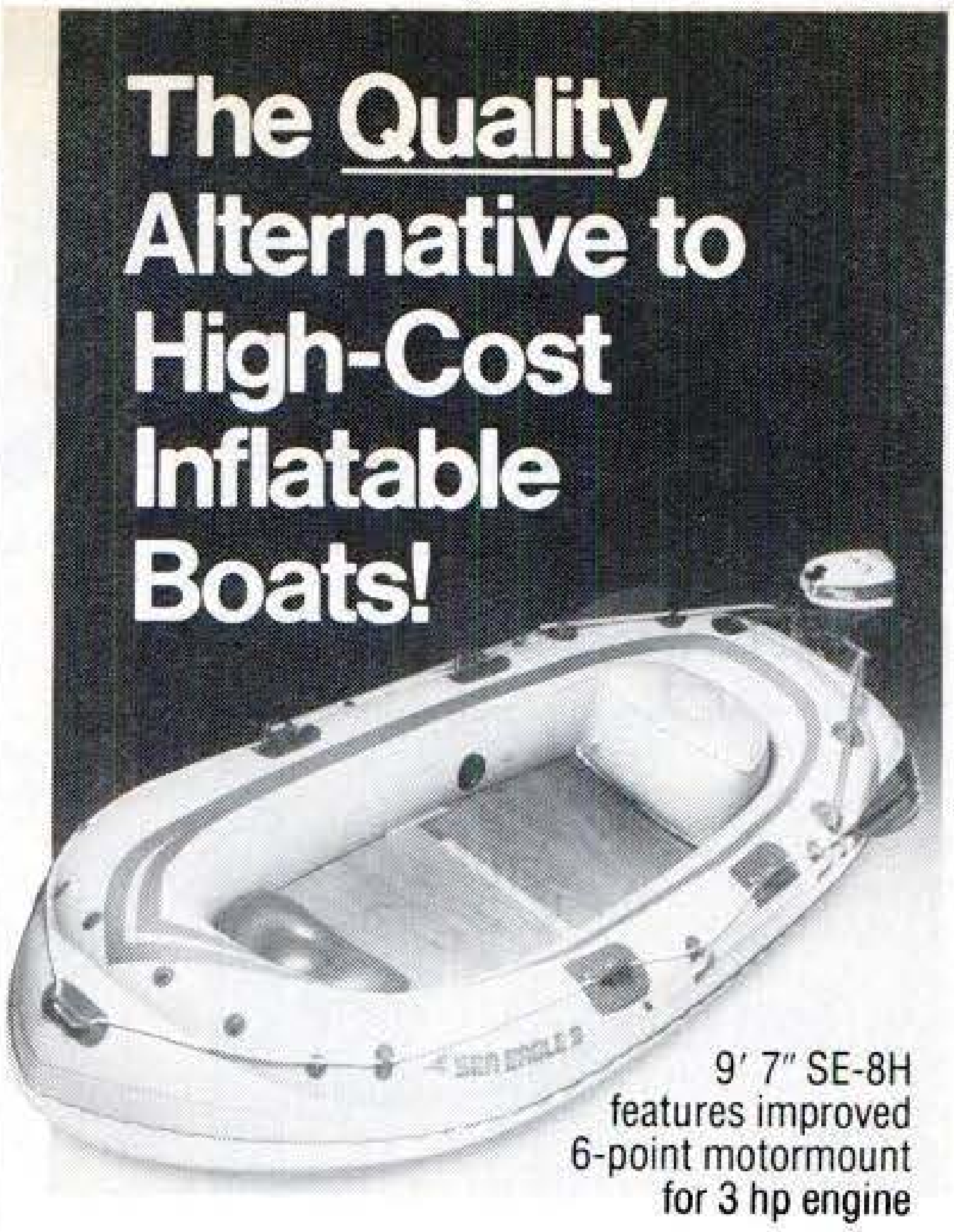
With this large a panel you can make the end grain as smooth as glass. Level the top, working down from coarse to fine sanding belts. A high-speed (4,000 rpm) disc sander with a sponge-backed wheel from an auto-paint store does a fast, smooth job on end grain. Eighty-grit paper on the wheel quickly removes any scratches left by the belt sander. However, some work with the orbital sander is still required to remove the glazed effect of unidirectional sanding.

Construct the table-leg assembly and drawer as shown in the drawing. Lightly sand the entire job, and you're ready for finishing. The exposed end grain in this piece will cause the top to shift if the bottom is not sealed against humidity, so the very first finishing job is to *thoroughly* seal the underside. Use commercial sealers, shellac, or thinned varnish. Then permanently install the leg assembly.

Because the top surface will drink a tremendous amount of finishing oil, partially seal it with a light coat of vinyl penetrating sealer (I ordered mine from Craftsman Wood Service), then apply a coat of sanding sealer to the aprons and legs. Follow the sanding sealer with a couple of coats of varnish, and you're ready to put the top finish on and *into* the wood.

You may be tempted to use salad or vegetable oils on the top: Don't—they never dry. Don't use salad-bowl finishes, varnish, or other surface finishes either, because they will chip and show knife marks. Carefully sand the top to bare wood (the penetrating sealer will be far down in the pores), and apply a clear finishing oil, like Watco Danish oil. Let your first coat cure a couple of days, then apply a coat each day until the surface won't absorb any more. These finishes contain toxic solvents, so wait at least a week before allowing food to contact the top. Install the casters.

Your butcher-block table top is now ready to withstand years of slicing without showing knife marks. It will be used and treasured by your children, too—assuming they haven't already prevailed on you to make duplicates for their own kitchens. PS



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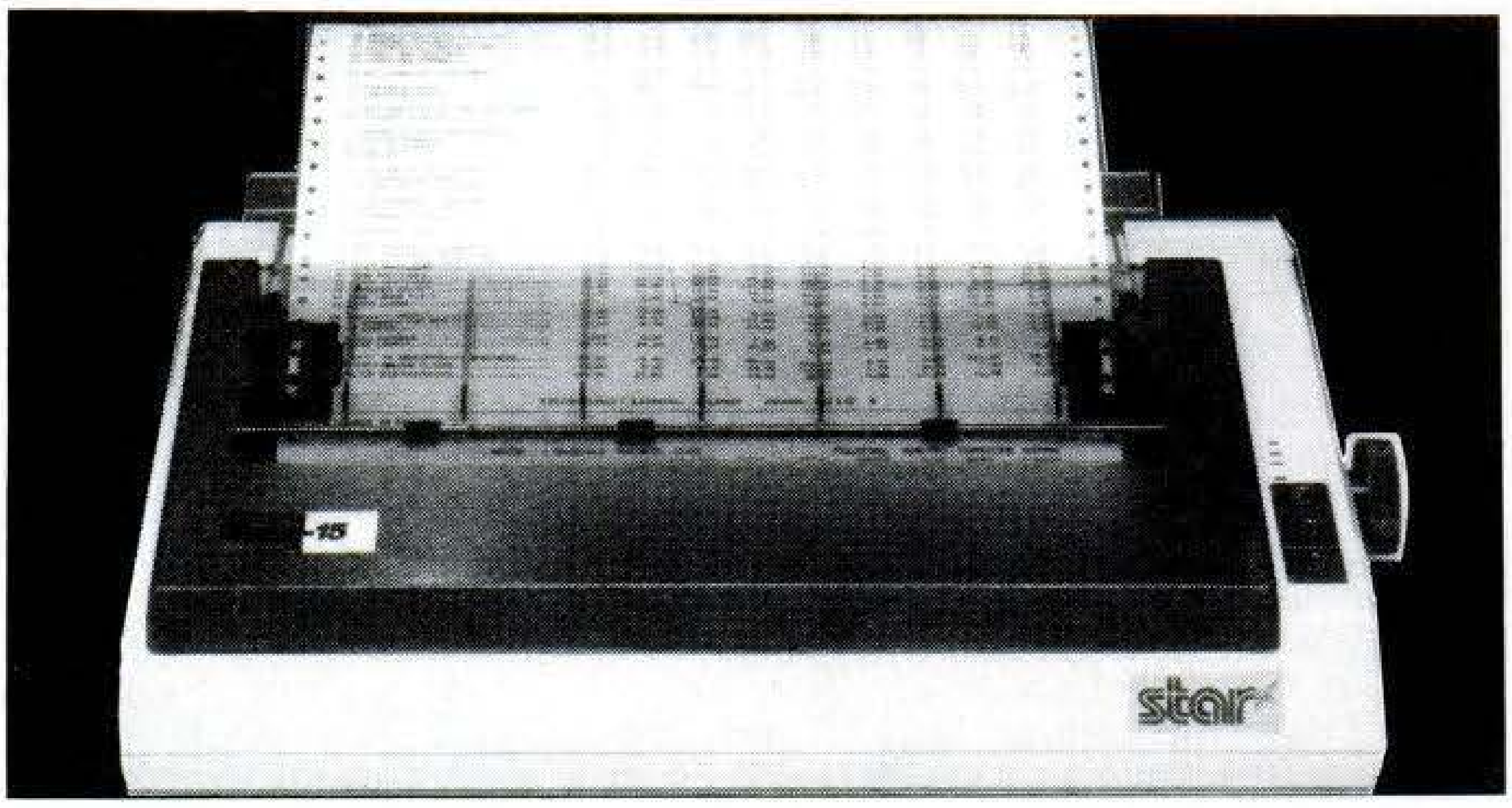

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[Continued from page 75]

they'll realize that they can up the volatility again and make more trips to the bank."

The problem is worse in some areas than in others. "The more progressive oil companies have modernized their refineries to take care of the crude they have to work with," continues Colucci. "But the smaller guys are being pushed for octane. They don't have the facilities for refining the octane into the gasoline. So they're more likely to go out into the spot market and buy alcohols and other higher-octane feedstocks that you wouldn't ordinarily put in gasoline because they push up vapor pressure."

Increasing emissions

Another problem: When the EPA set auto emissions standards several years ago, gasoline was running around nine pounds in summer. Now, with averages higher, hydrocarbon emissions are up. A General Motors research team recently checked the emissions of cars across the country. They found that with RVP figures averaging around 10.5 pounds, emissions were up sharply. They also found that reducing pressure from 10.5 back to the nine pounds that was standard just a few years ago would reduce hydrocarbon emissions by nine to 25 percent. A GM technical paper points out that gasoline with high pressures overloads the current carbon canisters, which were designed to reduce pollution but were designed for lower pressure fuel. "Our canisters are simply not designed to handle these high-volatility fuels," says Colucci. (Another related problem: With high-volatility fuels that overpower the canisters, a certain portion of the fuel pumped into your tank never reaches the engine. It evaporates, and the canister isn't up to stopping it.)

The car makers fear that the EPA will demand expensive fixes to reduce pollution—fixes the car makers say wouldn't be needed if gasoline were made with lower vapor pressures. "All the work we're doing to build emissions controls will go down the drain," says Jackson. "It's easy to see a scenario where we get more expensive requirements put on, and the volatility continues to climb. We end up chasing our tail."

Yet more problems

Volatility isn't the only thing that worries the car manufacturers. Among the others:

- Methanol may damage some parts of the fuel system. "Alcohols are corrosive and react with lead, magnesium, aluminum, and some plastics and elastomers [rubbers]," says Thring in his SAE paper. He also points out that such problems are minimal when alcohol concentrations are kept below approximately 10 percent. Chrysler reports that some rubber carburetor parts have been degraded and recommends that Chrysler car owners not use methanol blends. Atlantic Richfield, on the other hand, has done extensive testing of many different materials and has published scientific papers reporting no significant difference in those materials exposed to Oxinol—a methanol blend—over those exposed to pure gasoline.
- Water may cause alcohol to separate from gasoline. "Methanol has an affinity for water," says Clark. "It may then separate. If that happens, it rusts the inside of the mild-steel fuel lines and fuel tank and corrodes conventional carburetor and fuel-pump metals." Atlantic Richfield, which sells Oxinol, says it has solved the separation problem with the inclusion of a cosolvent—a substance called GTBA (gasoline-grade tertiary butyl alcohol). Atlantic Richfield has also placed great emphasis on dealers thoroughly cleaning all tanks and eliminating the danger of water contamination before methanol blends are delivered. (The company also claims that GTBA lowers vapor pressure.)

At the moment, most auto companies approve of the use of ethanol blends. But they're divided on methanol. General Motors, Ford, Toyota, Honda, and AMC say up to five percent methanol is OK. Chrysler, Nissan, Mazda, Subaru, VW, and Volvo say don't use it.

How clean?

Twenty years ago Mobil Oil Corp. began an ad campaign pushing high-detergency gasoline. It goes on to this day. However, the emphasis on detergency has not been industry wide. In fact, there is some evidence that average detergency is falling, and that some gas contains no detergent at all. This can be important, especially to carburetors and fuel injectors, which are sensitive to low detergency. To see why, visualize a fuel injector's pintle valve. It's built like a garden-hose nozzle. When the pintle is activated, it lifts off the conical seat and produces a cone-shaped spray of fuel. Each time the valve closes, fuel left on the end of the valve evaporates. After many repeated cycles, there can be a deposit from the evaporating fuel. And the space at the top of the nozzle gets smaller, upsetting the spray pattern. The result is loss of power, misfiring, surging, and poor drivability. A good detergent can prevent deposits or remove them if they have already begun to form.

So serious is this problem that GM vice chairman Howard H. Kehrl recently wrote to major oil-company presidents and executives. "It has become increasingly evident that port-fuel-injection systems are sensitive to fuel quality," he said. "Their performance can be seriously impaired by deposits that form at the injector tip and inhibit fuel flow." He said that GM dealers could clean injectors, but the deposits could come right back. GM has asked the oil companies to reveal their plans, and some have indicated they will raise detergency. The GM letter implied that the company might recommend such specific brands of gas for GM cars.

So just where does detergency stand? Nobody knows for sure. Fred Ruhland, an account manager at the fuel-products group at Lubrizol, one of the country's biggest suppliers of additives for both gas and oil, says the picture has changed in recent years. He says the amounts of detergents used are sharply down, but the effect is hard to know because some newer detergent materials are more effective than older ones. "A few companies were using between three hundred and a thousand pounds of detergent per thousand barrels of gasoline in the early seventies," he says. "Now many of them have come down to between three and five hundred pounds. A growing problem has come about because the majority of the oil companies use a treatment in the range of eight pounds of detergent per thousand barrels. And some companies —it's about thirty percent—use no additives at all."

Yet other companies have apparently been actually increasing detergency. For example, Hood of Mobil says: "We've improved the detergent package to the point where our regular unleaded prevents deposit buildup in carburetors and port fuel injectors, and our new super unleaded can actually clean up dirty fuel injectors. This recent Mobil development has won auto-industry praise, notably by the vice chairman of GM." Adds De Jovine of Atlantic Richfield: "We use more detergent, a higher cost detergent, now than five years ago."

One other important point: The gasoline business—like all others—undoubtedly has some dishonest operators. In fact, industry insiders talk about a phenomenon called splash blending. During the day, a tank truck filled with legitimate gasoline pulls into a service station and partly fills the holding tank. That night a truck filled with alcohol or a cheaper but higher volatility gasoline fraction

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pulls in and dumps another load. The result, of course, is out-of-bounds volatility, extra profits for the unscrupulous operator, and headaches—and maybe extra repair bills—for the unwary customer.

Many problems associated with bad gas undoubtedly come from such practices. Although the people who do such things don't usually admit it, one interesting case has come to light. Vic Rasheed, executive director of the Service Station Dealers of America, said he heard a blender at a recent trade meeting say: "I just add until they start complaining."

What can you do about it?

First, buy gasoline at stations that have pumps with labels saying the gas contains detergents.

Second, avoid buying gas at a station that gives you a tankful of problem fuel. You can also recognize that all gasoline is not alike. If you suspect that car misbehavior may be gasoline related, try another brand of fuel before attempting repairs. And when you find a gasoline that works, stick with it.

Finally, as with most other products, you're most likely to get quality from a reputable company with a reputation to protect.

What's the outlook?

Cars will undoubtedly be made more tolerant of high-vapor-pressure fuels. Fuel systems will be and are being designed to remove materials likely to be damaged by alcohol blends. More cars are appearing each year with fuel injectors. And fuel injectors, though sensitive to fouling, are more resistant to vapor lock and fuel foaming. Fuel pumps are being designed to pump more fuel, reducing vapor-lock sensitivity. And anti-foaming devices are also being built into fuel systems.

There is also a move toward state regulation. Twenty-eight states have requirements for labeling alcohol content, if any, and a few—such as California—actually regulate vapor pressure. Some are urging the EPA to attempt to control emissions by requiring certain levels of detergency, vapor pressure, and other qualities. The EPA reportedly has these matters under study. The Motor Vehicle Manufacturers Assn. has been urging complete disclosure on the label attached to every gas pump.

The fact is that both the auto makers and the oil companies are in very competitive businesses. Fuel with good detergency, no alcohol, or a lower vapor pressure costs more. In a study commissioned by the EPA, Bonner and Moore, Inc., an oil-industry consulting firm, estimates that vapor-pressure reduction costs 0.6 cent per pound of reduction per gallon of gasoline. A two-pound reduction would cost almost 1½ cents per gallon.

The oil companies, of course, would like to keep prices down. They'd rather see the automobile companies make the fixes. That would increase the cost of cars, of course. The car companies, on the other hand, would find life easier if average vapor pressure were brought back to the old standard level of about nine.

It's not the first time that similar situations have developed. The truth is that gradually new technologies will evolve that will chip off bits of the problem here and there; prices will go up a little for fuel and a little for cars; and some new problem will come along to attract our attention. In the meantime, you can be aware of the kinds of problems bad gas can cause and, so armed, have a good chance of being one of those drivers who don't get caught. PS

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[Continued from page 71]

super-Dagwood sandwich precisely spaced, and protecting the delicate membranes from the noise and vibration of the shuttle flight, would have been a nightmare, says Meyer. The solution to the problem came out of a hole in a ski jacket.

"Skip Johnson, our mechanical design engineer, was sitting in our office one day," recalls Meyer. "He pulled some of the plastic stuffing out of a hole in his ski jacket and said 'You know, that looks nice. Maybe we could use that.' Later, somebody put a backpacker's magazine on my desk, open to an ad for this artificial eiderdown. And it turned out that these polyolefin plastic fibers were the ideal material and thickness for us. So we bought a supply and an industrial sewing machine, and started sewing. The place looked like a blanket factory for a while."

The X-rays from the blankets are detected by ionization chambers interleaved within the blankets. These consist of octagonal frames, each strung like a giant harp, with 200 hair-thin steel wires. Stretched over the frames is a covering of aluminized Mylar plastic film, and the chambers are filled with a xenon-helium-methane mixture. When an X-ray emitted by the fibers passes near one of the wires, an electrical signal is produced, telling scientists the energy and precise trajectory of the particle.

"So far, we know the elemental composition only up to less than a hundred billion electron-volts," says Meyer. "We can go up an order of magnitude with our detector. It is very crucial to get up to these energies because there are hints from ground-based studies that the composition of the particles might change with higher energies."

Such studies of air showers, says Meyer, indicated that some of the high-energy cosmic rays plowing into Earth's atmosphere were as heavy as iron, but analyzing the showers is so complex that no one can be sure.

"There have been ideas that pulsars might be responsible for accelerating particles to very high energies," says Meyer. "And one would expect a lot of iron on the surfaces of pulsars. But the theorists have, so far, only demonstrated that the necessary energy would be there, and have not quantitatively shown how particles could be accelerated."

NASA plans to launch the Chicago Egg again in 1988. It will rejoin the many instruments that will roam the solar system and scan the skies from Earth over the next decade. And the storm of high-energy stardust called cosmic rays will continue to bring news of the galaxy beyond. PS

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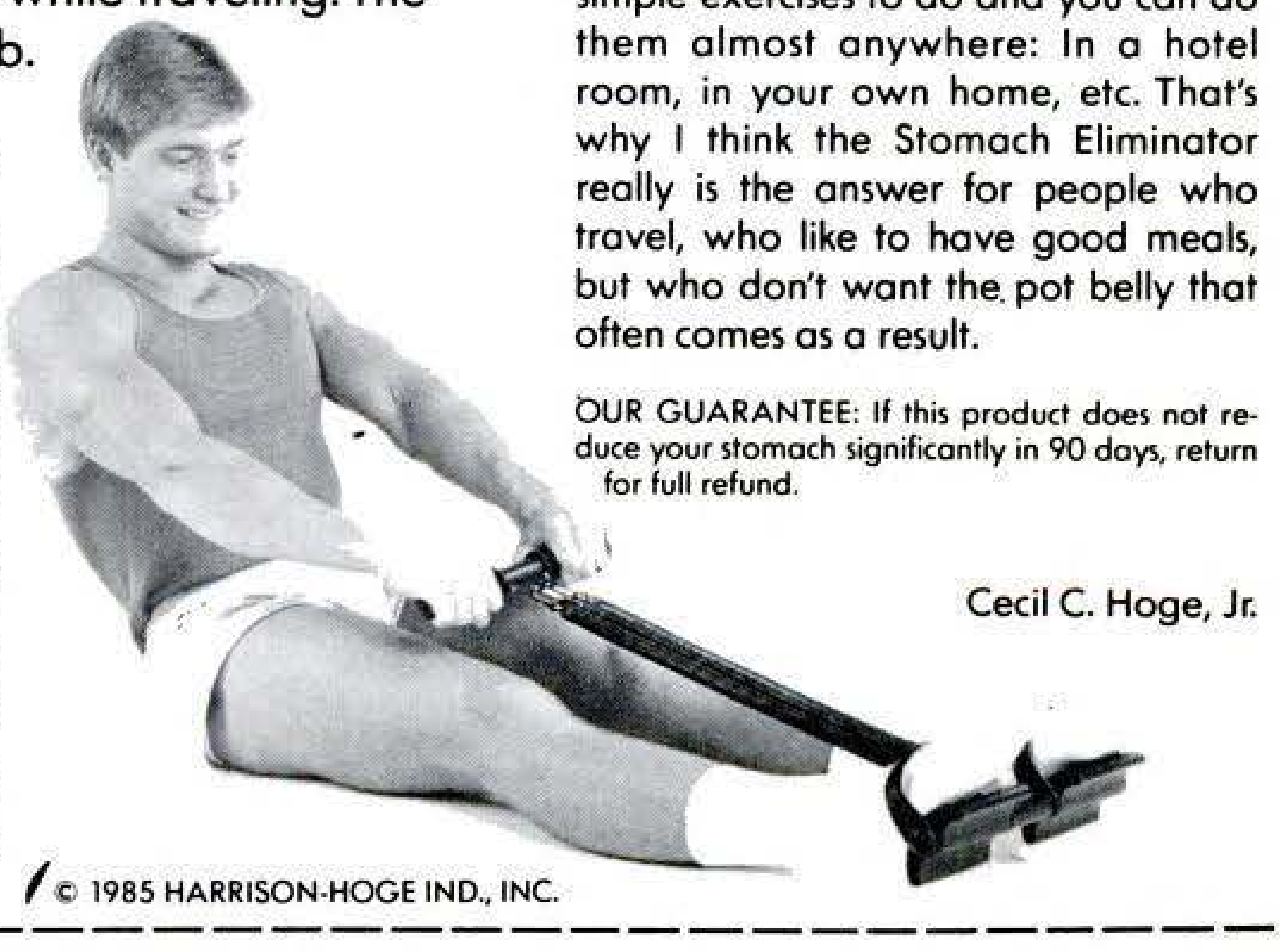

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It's a pterodactyl

[Continued from page 79]

Working in AeroVironment's small development facility in Simi Valley, Calif., project manager Alek Brooks and his team worked with the paleontologists to push the pterodactyl design through a series of steps. They began with a toy-sized model powered by rubber bands, then moved to progressively larger and more realistic reptiles. At one point, Simi Valley residents were startled to see an AeroVironment van racing up and down the streets with a quarter-scale pterodactyl strapped to its roof.

"It made a wonderful flight simulator," says engineer Martyn B. Cowley. "We put several hundred flights on that bird."

As they built the various models, the design team dealt with the problem of fabricating an extremely light internal structure that would be strong enough to withstand the stress of wing flapping. They also needed to create a skin that would be both tough and realistic. The wing-flapping mechanism itself would require months of development. Finally, they had to find a way to launch the beast.

Building bones and skin

Before deciding on the materials that make up the pterodactyl's structure, AeroVironment tested a full range of options, including aluminum, birch, and plywood. "We settled on carbon-fiber tubes for the bone structure," Brooks told me. He handed me a two-foot section just one inch in diameter and challenged me to bend it. I couldn't. The tubes, carefully and precisely made in the AeroVironment shop by wrapping carbon fibers around a form, are stronger than steel but weigh one-fifth as much.

Far smaller tubes, serving as internal struts, were handmade for the wings. Once assembled, the result is a wing with strength and rigidity. Yet it remains capable of twisting and bending slightly in response to aerodynamic pressures. The body covering and bulkhead around the flapping mechanism are a honeycomb material sandwiched between carbon-fiber sheets.

With the wing structure determined, the team faced the question of skin. The covering must be strong enough to withstand the rigors of flight yet be realistic enough to fool the eye. After trying and discarding a variety of materials, they settled on a thin latex film epoxied to a lightweight packing material. Engineer Ray Morgan showed me the result—a slightly mottled, gray-brown surface that might have fooled a pterodactyl's mother.

"It feels just like dinosaur skin, doesn't it?" Morgan said with a grin. I had to agree... I think.

How does the team expect this dinosaur replica to fly? MacCready sums up the basic design:

"In response to an on-board computer, the replica maintains stable flight by moving its head from side to side, extending fingers midway out on the wings, twisting the wings, and swinging them forward and backward," he says. "All this goes on while the battery-powered 'muscles' flap the wings to provide propulsion."

Primary power comes from two powerful samarium-cobalt electric motors. Small enough to hold in your fist, the motors draw energy from nickel-cadmium battery packs to produce a full horsepower each. These motors drive the jack shaft that flaps the wings (see drawing). A third, smaller, motor mounted toward the rear of the body controls the fore-and-aft sweep needed as the wings flap.

To reduce stress on the motors, the pterodactyl specialists designed an ingenious counter-tension system—basically a set of 66 rubber-band "muscles" running from the jack shaft up through the lizard's neck.

"When the wings flap up or down," Brooks explained, "a cord winds onto a spindle and stretches the bands. That provides a counter tension on the motor so that the wings always return in the opposite direction of where they are."

Although the counterforce relieves tension on the motors, reducing the force needed to move the wing, the practical effect is to conserve battery power. Even so, maximum flight duration for the pterodactyl will be barely five minutes.

The wings themselves generate considerable lift. Morgan told me to flap a nine-foot wing used in bench testing. With each down stroke, I could feel the distinct forward thrust and see the wing twist slightly under pressure.

But will the machine really fly? To find out, designers first tested a pterodactyl-shaped glider. Its wings didn't flap, and it crashed repeatedly. But after scores of minor changes and reflights, the scale model achieved modest stability.

Those tests also provided the solution for getting the reptile replica into the air—a two-wheeled launch trolley with a rearward tail assembly. Towed behind the van, it leaps into the air, carrying the machine to altitude. Once aloft, the trolley falls away, and the pterodactyl is on its own.

But then Brooks faced the problems of in-flight stability. A pterodactyl has no tail. Its long neck and head are at the wrong end for modern aircraft design. "The head has to move left and right to act as the rudder," Brooks told me. "Without that motion, it would flip around backward in a second."

Head motion is so critical that it must be controlled automatically. The builders designed and built a special autopilot to do the job. It's about the size of a soap dish, but it monitors head movement via sensors and constantly feeds corrections to servomotors.

The autopilot also controls wing sweep. The wings must move fore and aft to provide pitch stability, Brooks said. To show me these motions, he used the final 43¼-pound, half-scale model. Mounted on a test stand and still without its skin, the skeletal lizard was an eerie sight.

Wings in motion

Brooks started its motors—and immediately there was a sharp and definite forward motion of the 18-foot wings, combined with powerful flapping.

At each wing stroke, the counter-tension bands twanged in and out. The head shuddered and jerked, with the closed beak twitching at its tip. Flapping at about one complete stroke per second, the wings twisted and moved front and back, and up and down, all at the same time.

Additional wing control comes from the webbed hands at each main wing joint. "The hands act as spoilers," Brooks said. Latex webbing between the fingers gives the hands "real air-brake quality," he added. A second autopilot controls the hands.

So sophisticated are the computer-controlled autopilots that a standard model-aircraft radio system is used—unmodified—to control the pterodactyl's flight. The ground controller uses the system to initiate turns and altitude changes and during takeoffs and landings. To land, the creature plumps onto its reinforced chest and belly, which serve as a skid.

Bench testing of the half-scale model ended last October. Brooks wanted to finish flight tests by the end of 1985 and then build a full-scale version. By late spring the model was due to be filmed in Texas. Then would come the flights at the National Mall.

But flight tests on the half-size model ran behind schedule, and MacCready scrapped plans to build a larger one. "The 18-foot version is capable of achieving all the original goals," he says.

"After all, no one in aviation—except makers of small, tissue-covered model airplanes—has ever achieved flapping-wing flight," adds Cowley.

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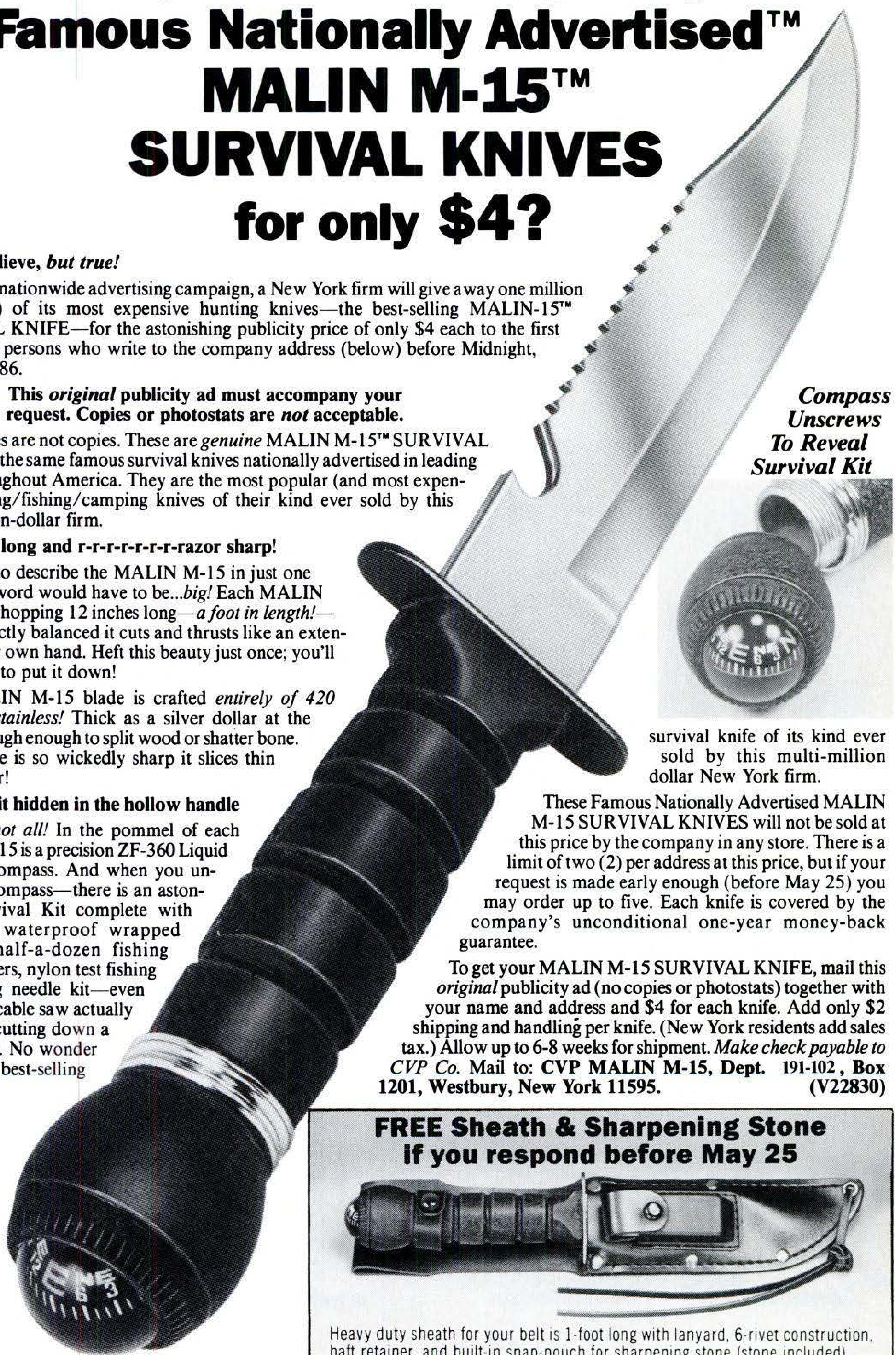

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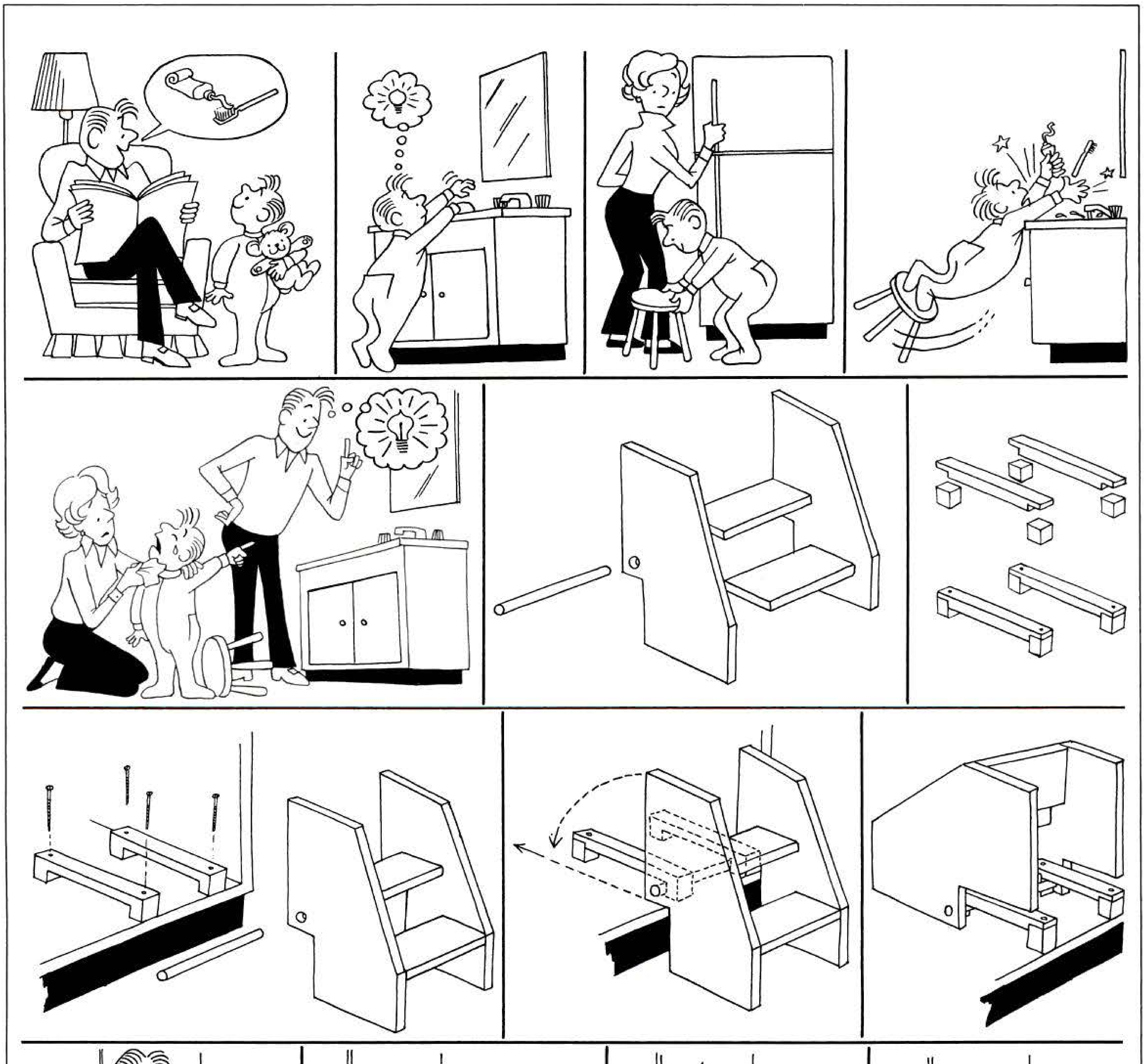

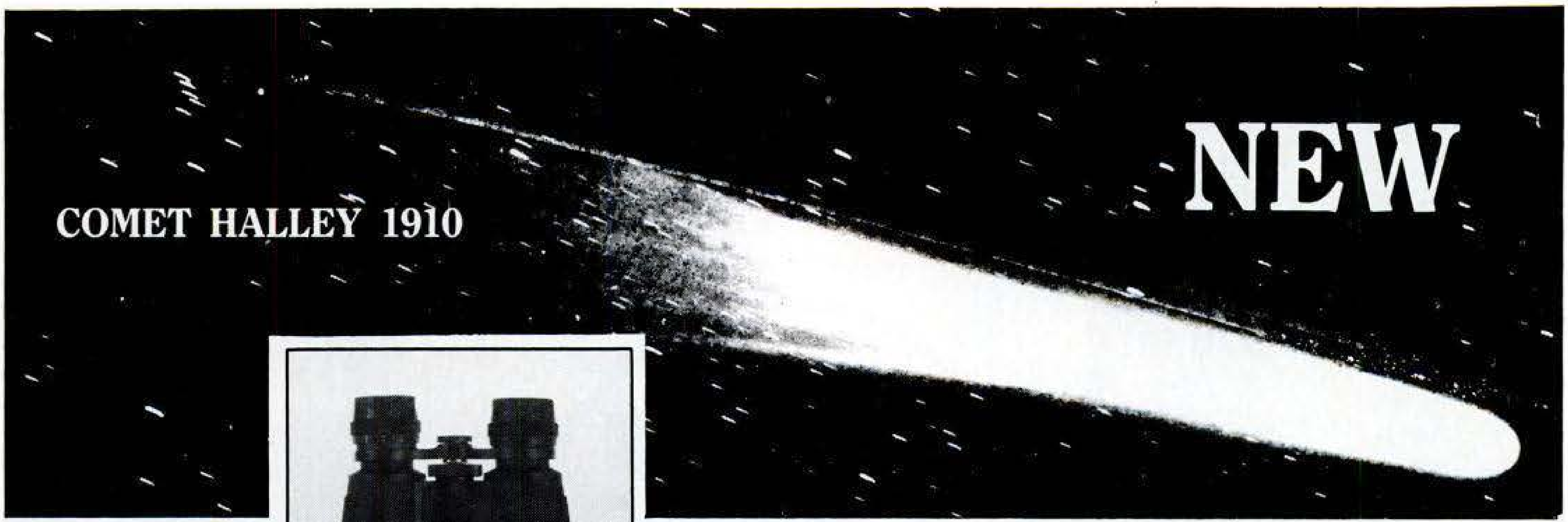

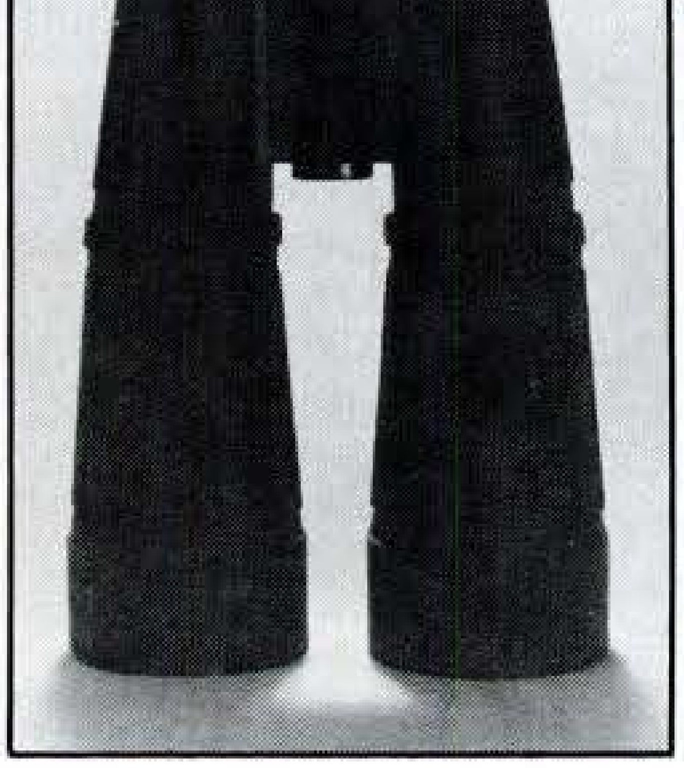

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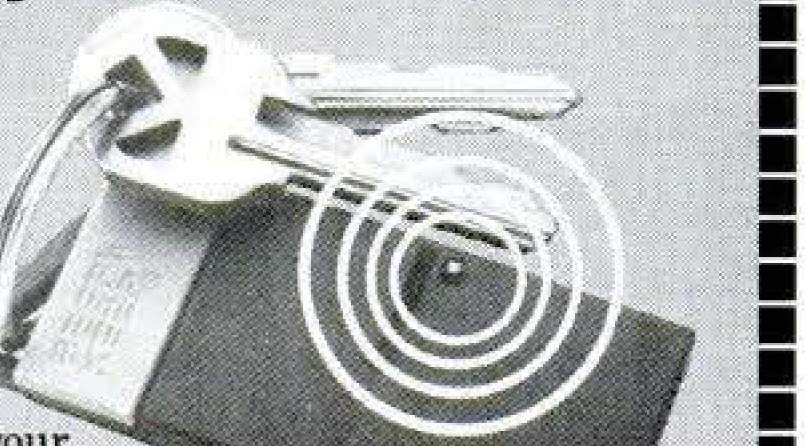

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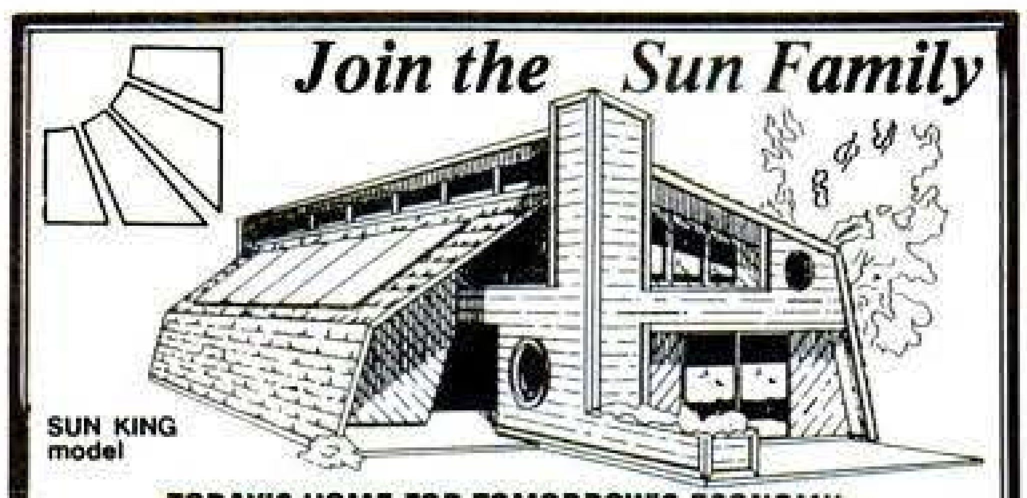

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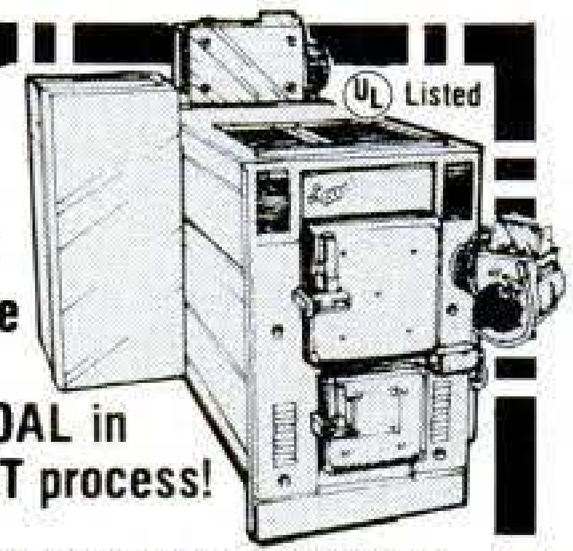

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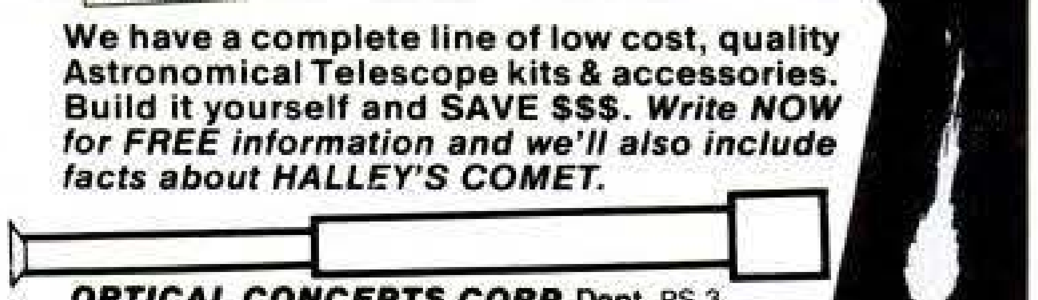

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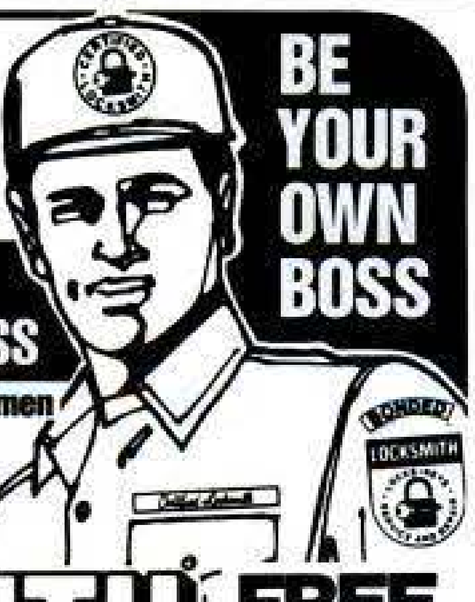

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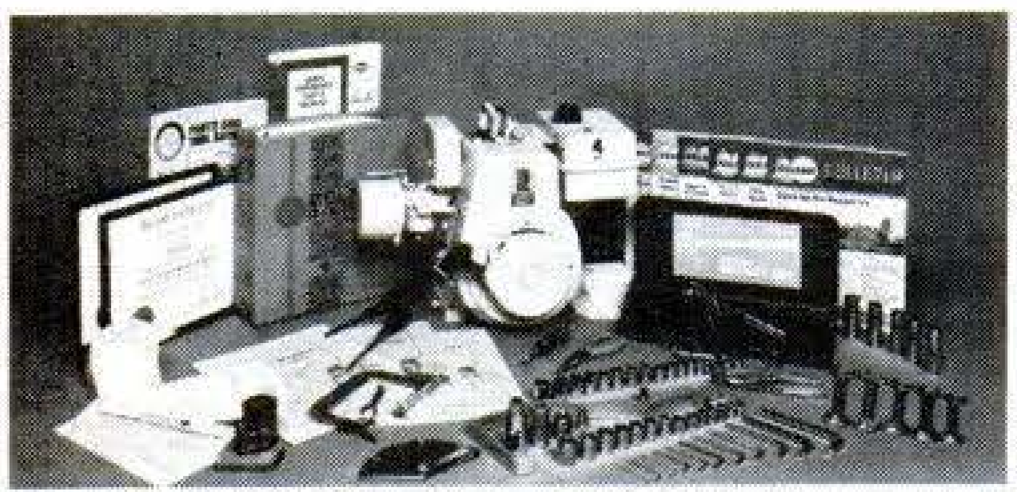

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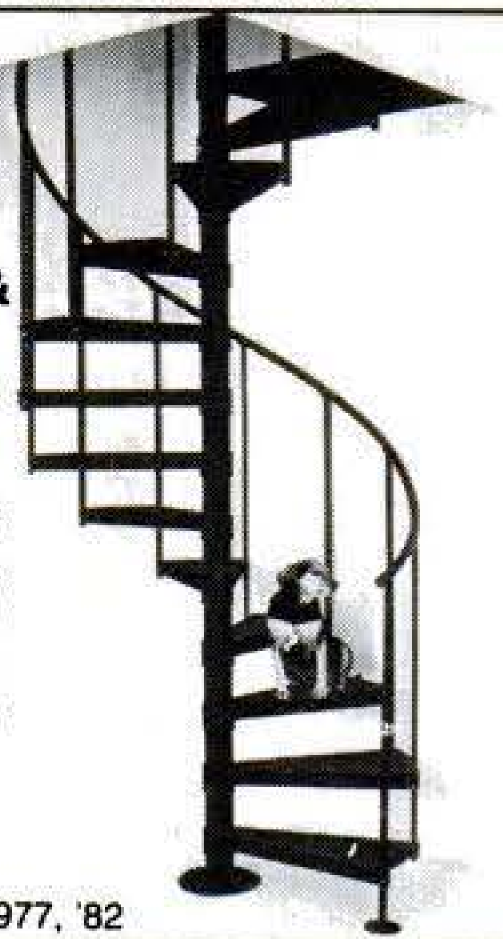

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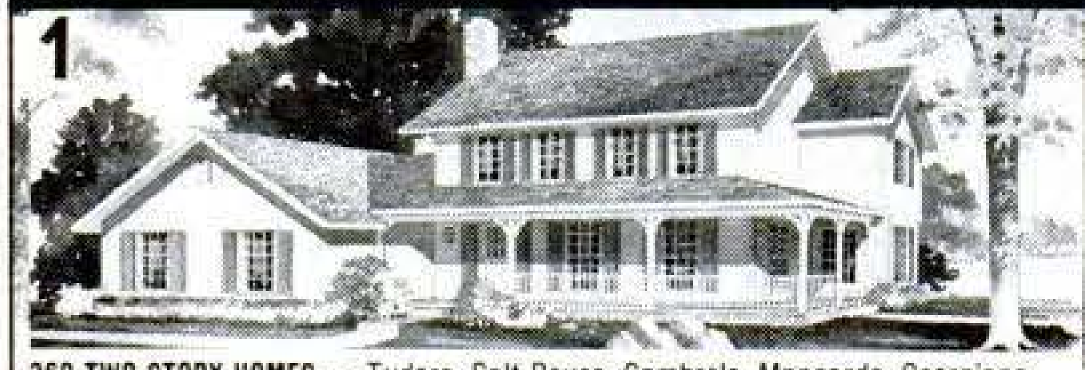

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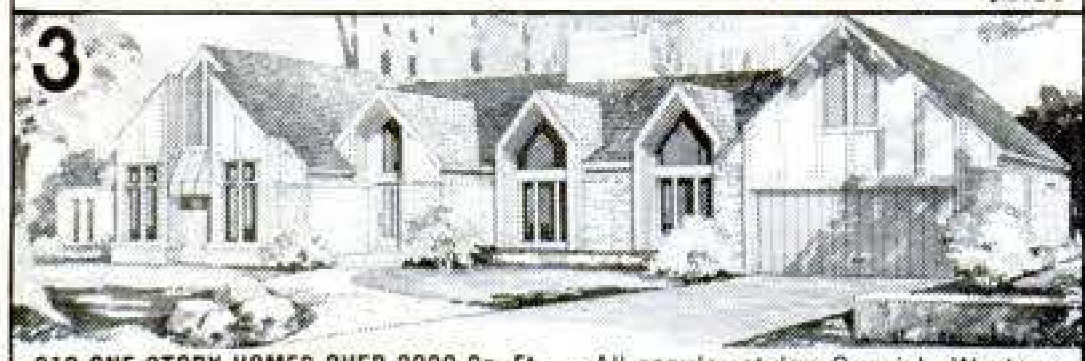

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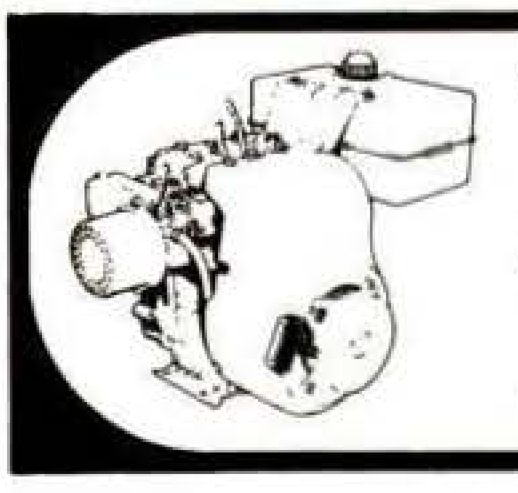

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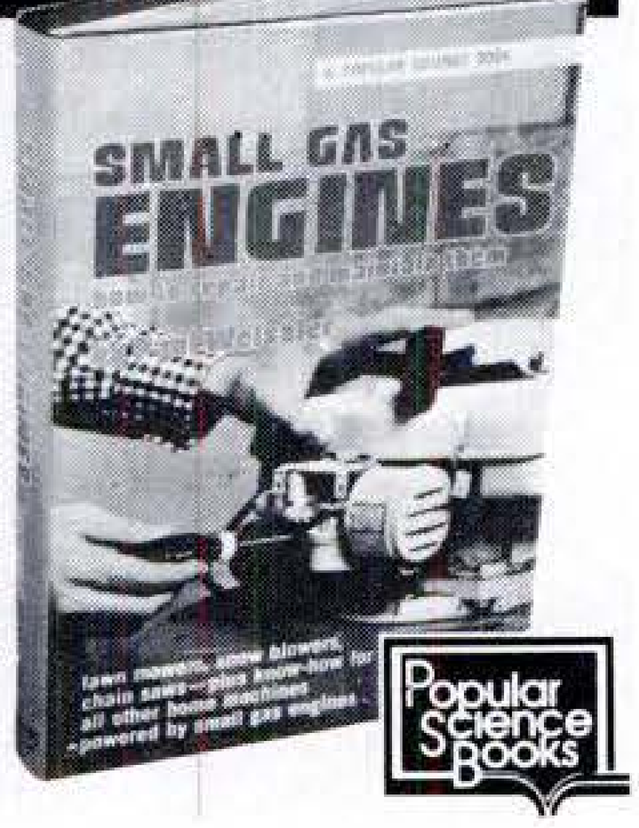
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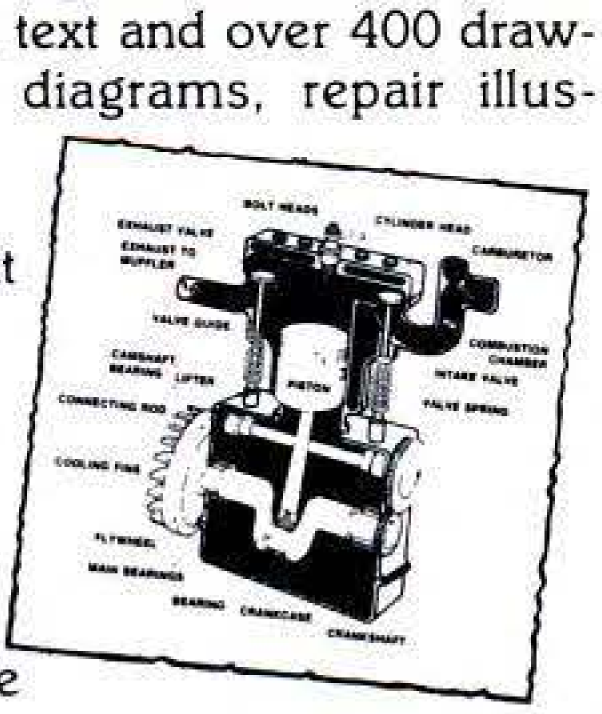

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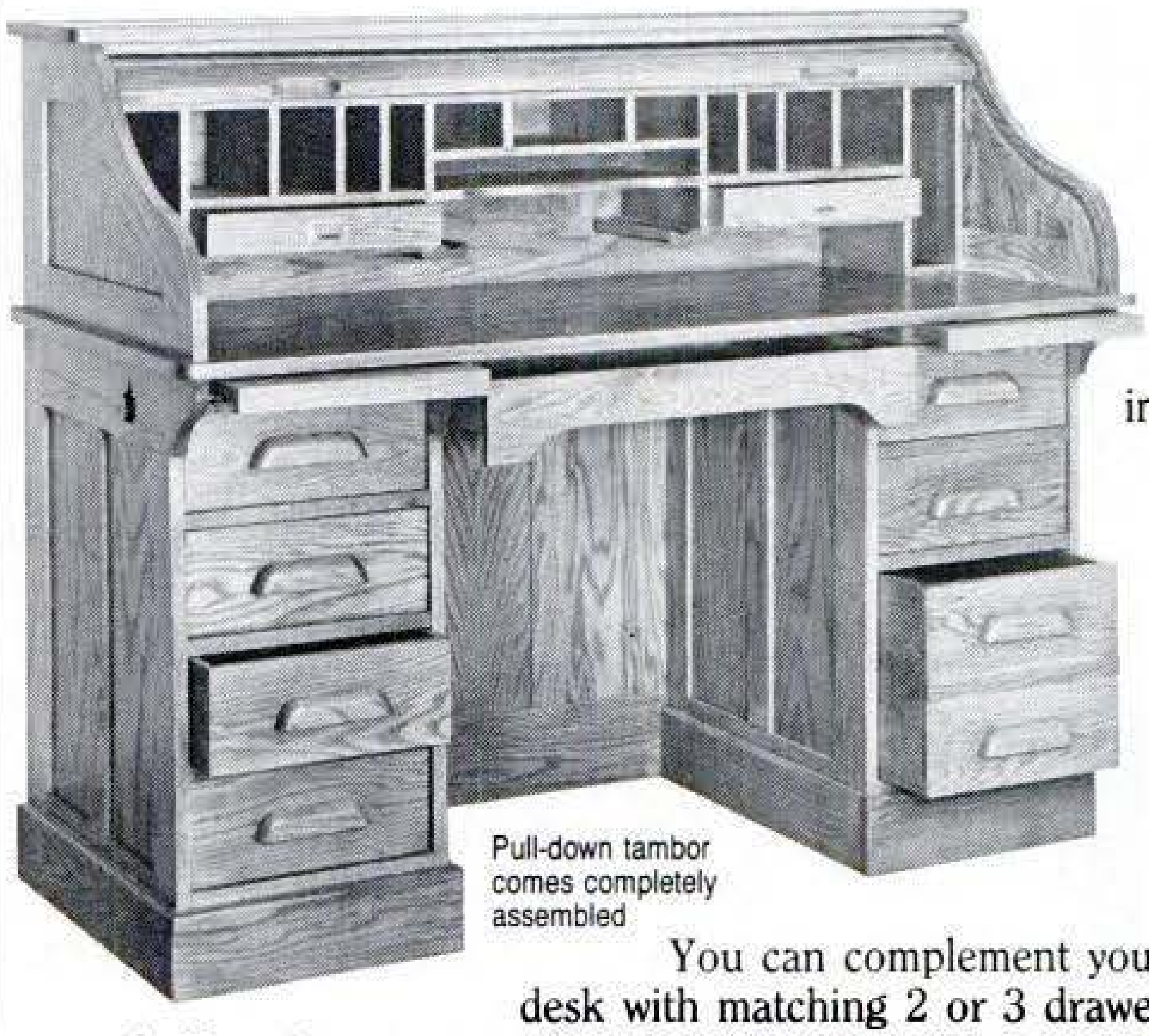

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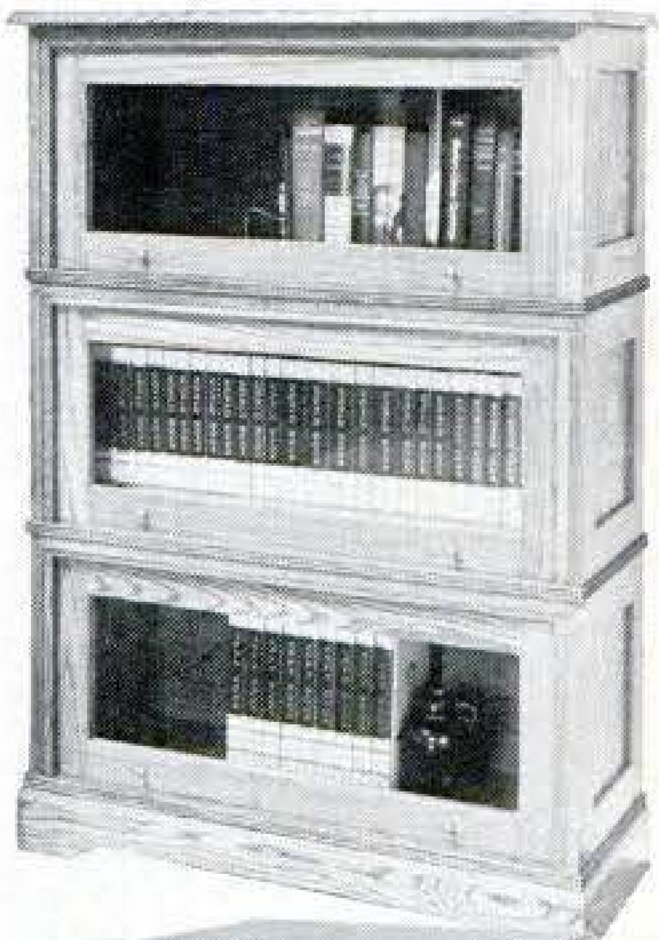

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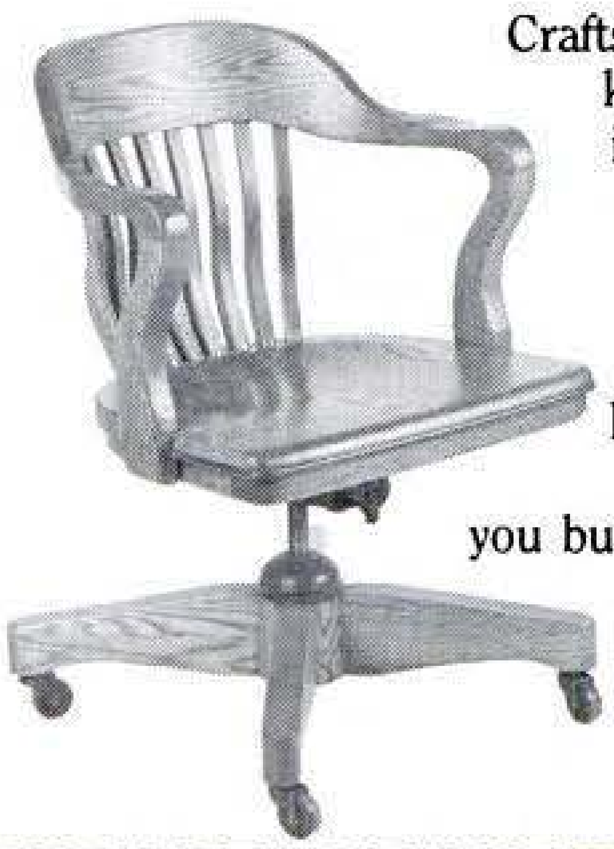

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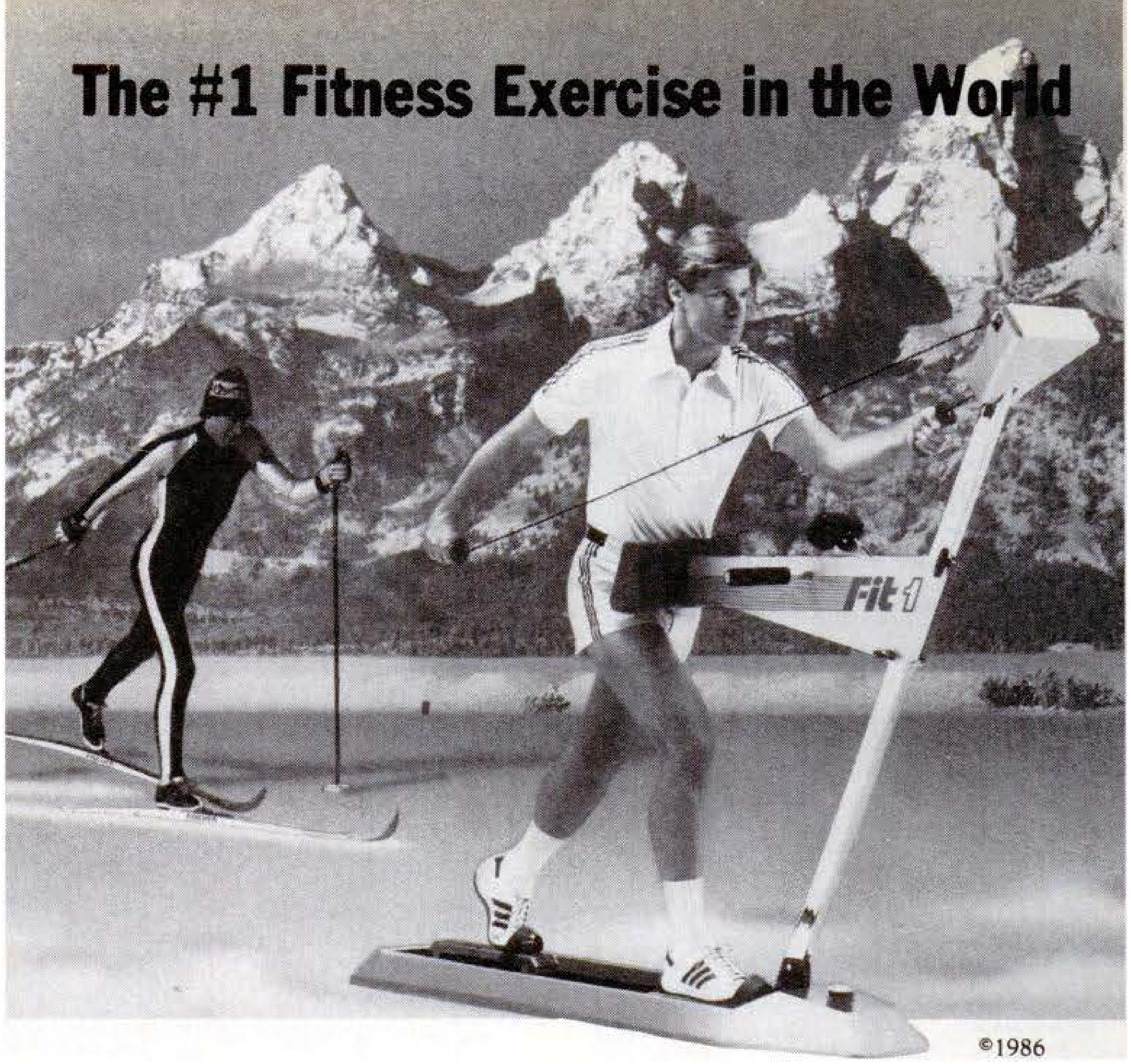

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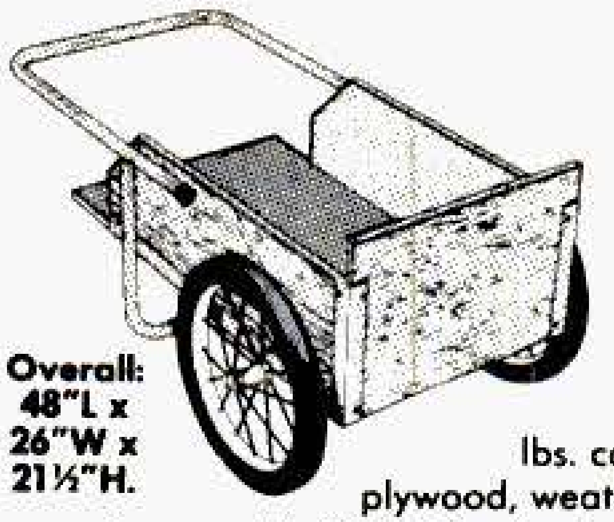

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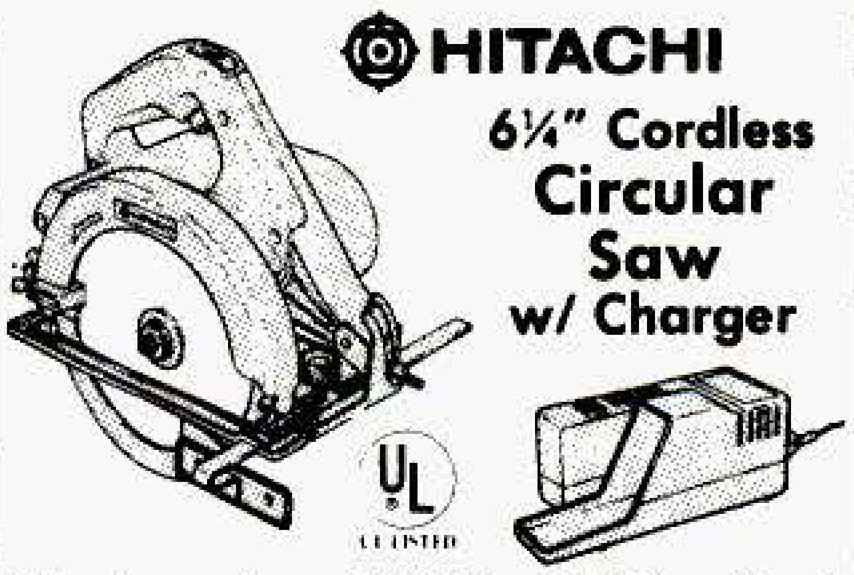

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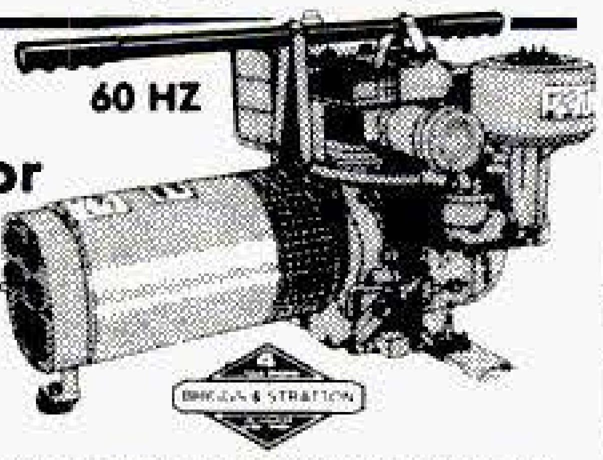

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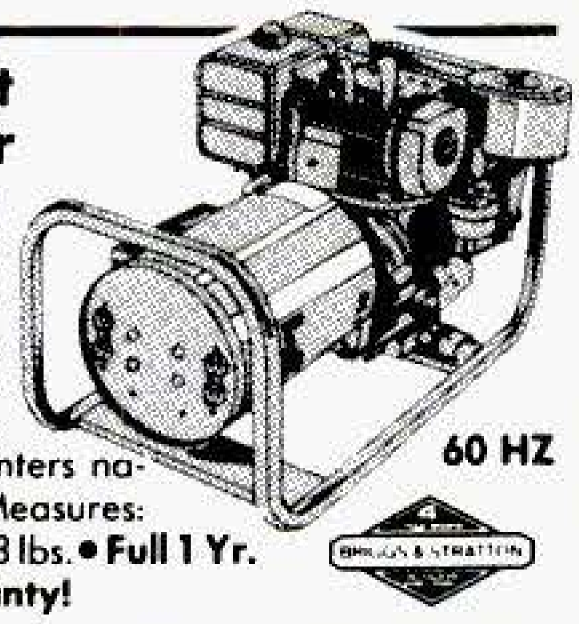

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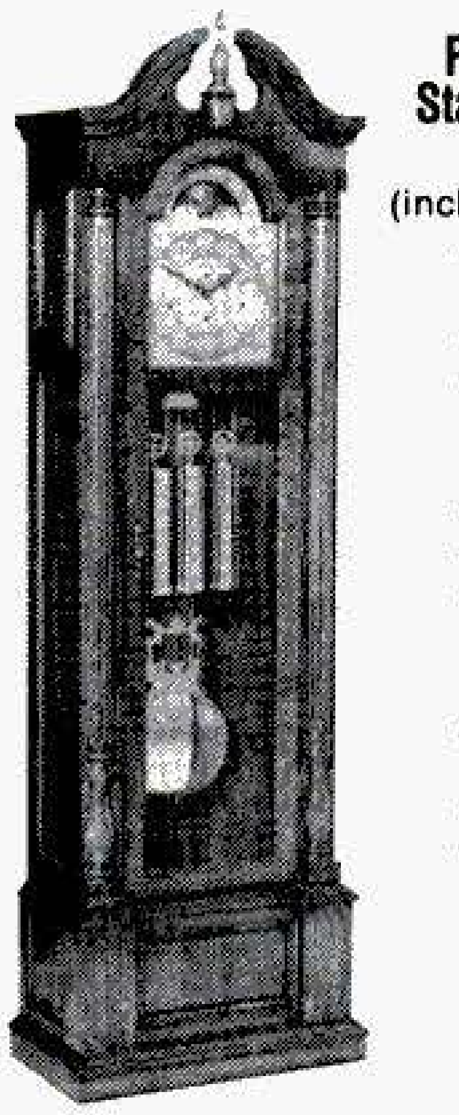

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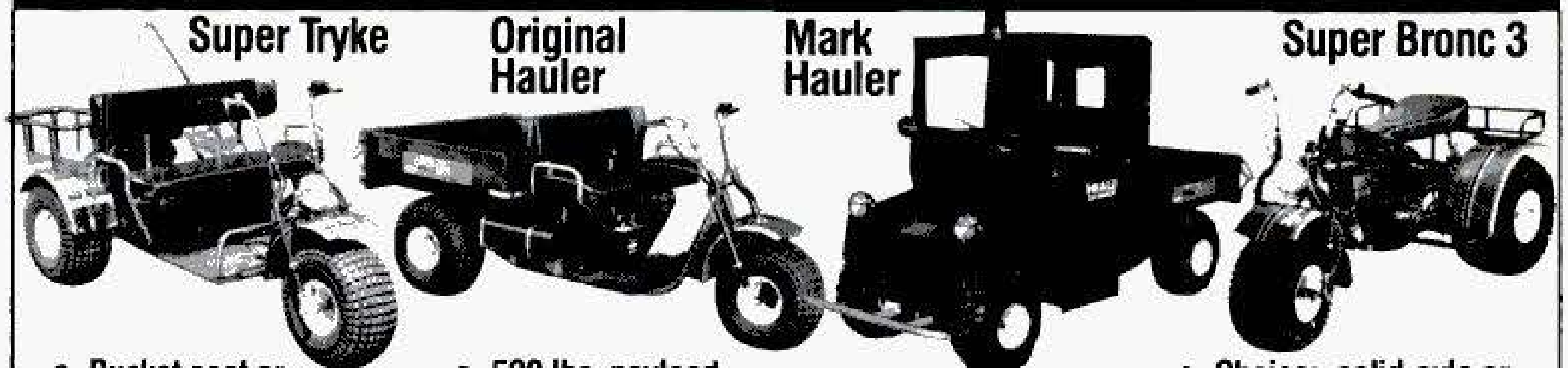

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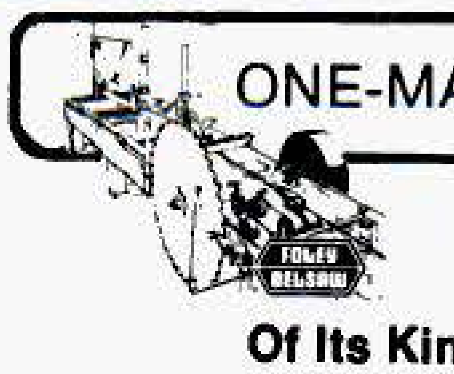

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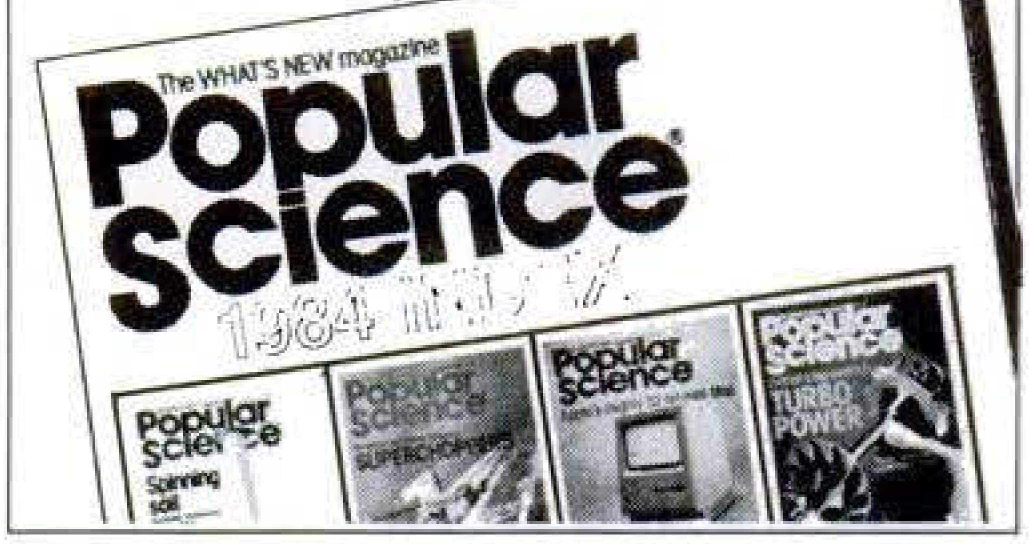

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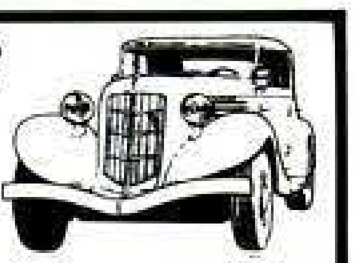

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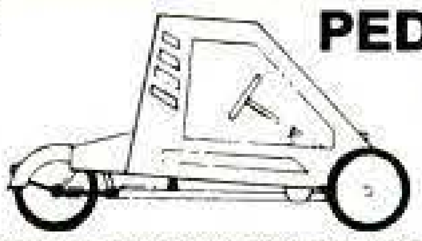

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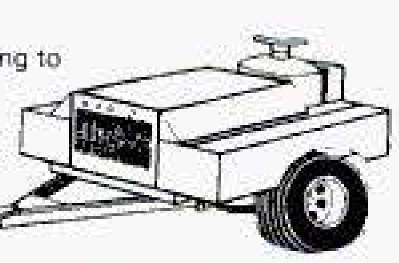

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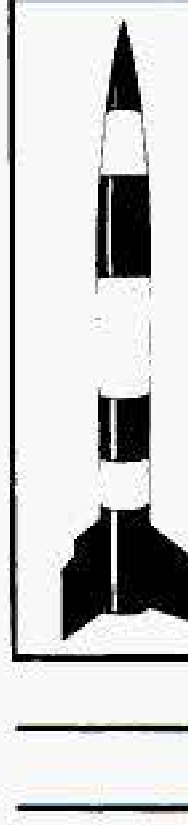

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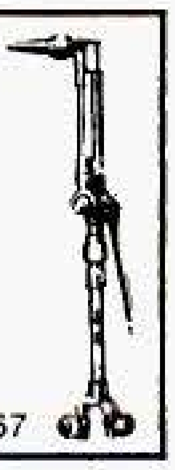

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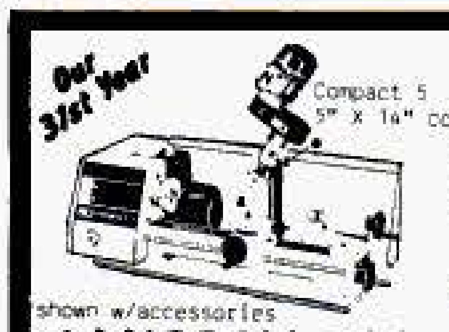

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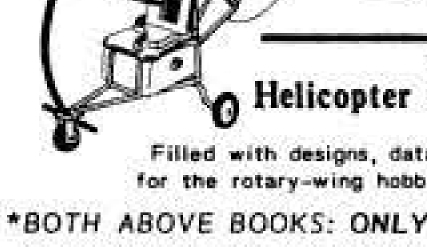

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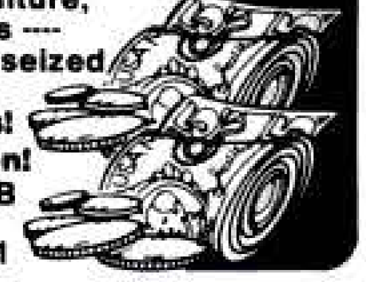

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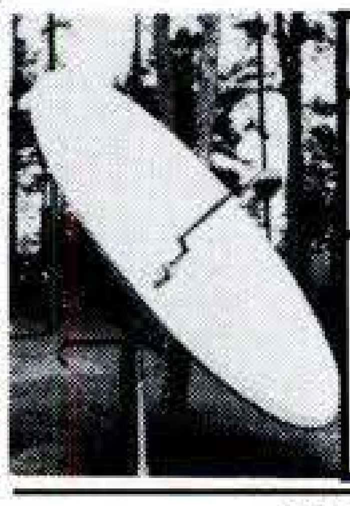

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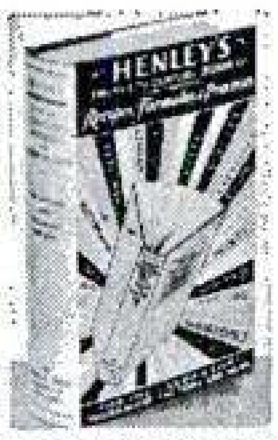

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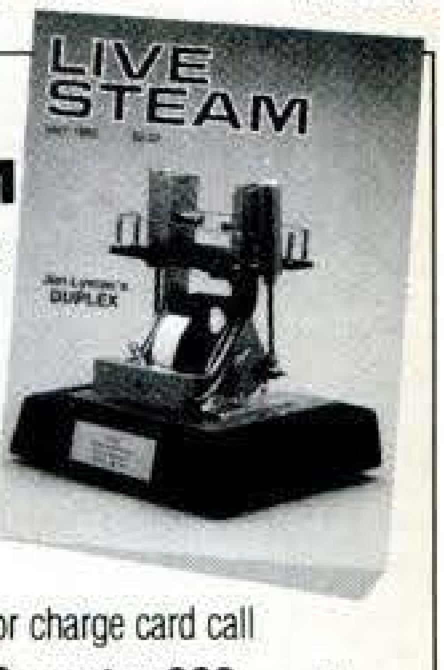

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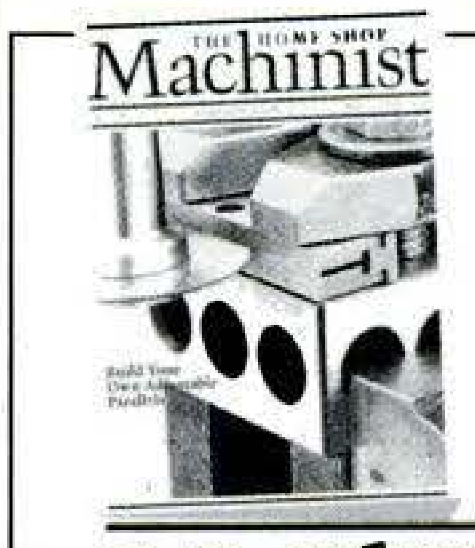

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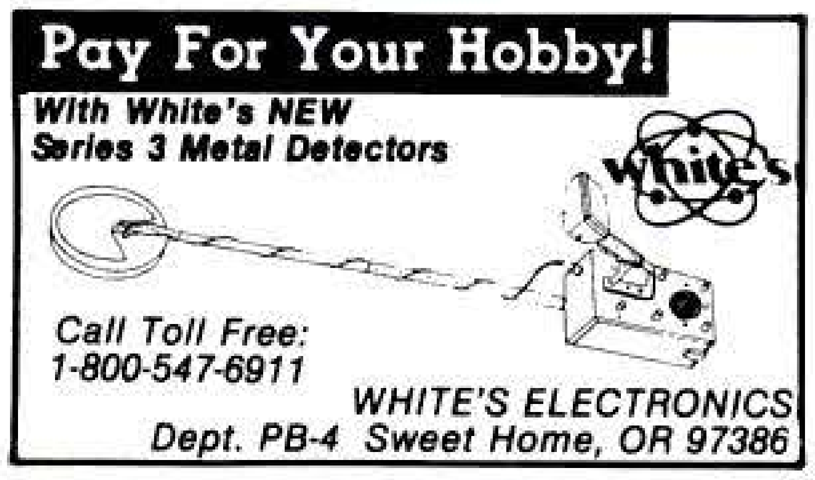

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Booklets, catalogs, and folders listed below provide reliable information, illustrations, and specifications to help you in planning the purchase of a variety of products or services offered by these dependable companies. The convenient order form will save you time and postage. Orders will not be processed unless accompanied by the $1 handling fee.

301 Household Inventory Record A packet from Allstate Information Center provides a handy room-by-room inventory record for your personal property. The package includes tips on identifying lost or stolen property and provides a place to record where important papers are kept. Free

302 Personal-Computer Tips In its detailed color brochure, CompuServe, America's largest information service for personal-computer users, tells how to obtain access to its vast data banks for reference material, news wires, financial and travel information, electronic mail, games, and lots more. Free

303 Concrete and Masonry Repair A 15-page booklet from W. R. Bonsal Co. details its line of Sure-Fix concrete and masonry repair products. The booklet covers problem areas such as patching, resurfacing, anchoring, grouting, sealing, and much more. Free

304 Wood Machinery Delta's 44-page full-color catalog lists its wood- and metal-working machinery for the do-it-yourselfer and pro craftsman. It includes specifications and a list of dealers and service centers. $1

305 Hobbyist Catalog A 60-page color catalog from Edmund Scientific features telescopes with which you can view Halley's Comet, plus many hard-to-find and fascinating products for the gadgeteer and educator. Free

306 Personal-Care Showers Turn your bathroom into a spa. A full-color brochure from Interbath shows you how with a system that bubbles, tingles, pulsates, and adjusts to any height. The system also carries water- and energy-saving features. 50¢

307 Digital Thermostats A color brochure from Jade Controls describes the uses and benefits of the lowest-priced setback thermostat on the market. The J3000 allows multiple setbacks during any 24-hour period. Free

308 Unusual Items Johnson Smith's fun-filled catalog, where the unusual is the usual, offers 1,000 hard-to-find novelties, hobby and sports equipment, jokes, tricks, scientific and electronic items, and much more. Free

309 Camper's Guide A 124-page directory from Kampgrounds of America lists KOA North American campgrounds. It comes complete with full-page, full-color travel maps. $2

310 Home Craftsman Makita U.S.A offers a 24-page full-color catalog on its new Home T.E.C.H. line, made especially for the home craftsman. The catalog provides complete information on the entire line, along with available accessories, practical applications, and suggested retail prices. Free

311 Terrace Doors A new brochure from Marvin Windows provides information on energy-saving features plus a variety of options and sizes for terrace doors. Color photographs show traditional, contemporary, and French styles. Free

312 Mercury Outboards Mercury Marine's new brochure describes the all-new smoothest-ever 8- and 9.9-hp fishing outboards, with full gear shift and tilt in the handle. The country's most popular bass outboard, the XR2, has been joined by a new 135-hp V6. Free

313 North Carolina Vacation The travel package from the North Carolina Department of Travel gives information on where to go, where to stay, and what to do on a vacation in North Carolina. Free

314 Window Technology An eight-page pictorial from PPG Industries details the heat-saving benefits of "The Intelligent Window," made with Sungate coated glass. The brochure also gives data about degree-days to help you decide how much energy is needed to heat and cool your home. Free

315 Satellite TV Buyer's Guide A 24-page buyer's guide from Satman gives details about free 100-channel satellite TV and how to shop for an earth station. It lists the lowest prices on equipment and tells how to install your own earth station quickly and easily. Free

316 Yard Equipment This color brochure from Snapper Power Equipment describes its durable, versatile line of walking and riding mowers, lawn and garden tractors, front- and rear-tine tillers, snow throwers, and attachments. The company's two-year warranty is also outlined in the brochure. Free

317 Visitor's Guide A 64-page full-color catalog from the South Carolina Division of Tourism features the state's historic cities, uncrowded beaches, world-famous gardens, blue lakes, green mountains, and graceful plantations. Great dining spots and shopping locations are also included. Free

318 Carpenter's Package An information packet from the Total Shop describes its complete carpentry package, which contains the five most-needed tools as well as the accessories to help you do the job right. Other specialized woodworking tools are featured, including a six-in-one power tool that is capable of sanding, drilling, and more. Free

319 Quality Cigars Get better cigars at better prices. Literature from Thompson Cigar Co. lists more than 100 different custom-made, factory-fresh cigars, which come directly from Tampa, Fla., the nation's fine-cigar capital. Free

320 Music for Your Home Wersi's new 55-page catalog features the latest inventions in music technology that let you build, update, and expand your equipment, and even hook up a home computer to help you play your own music. The company offers a toll-free number to provide you with complete details on a product, including final prices. Free

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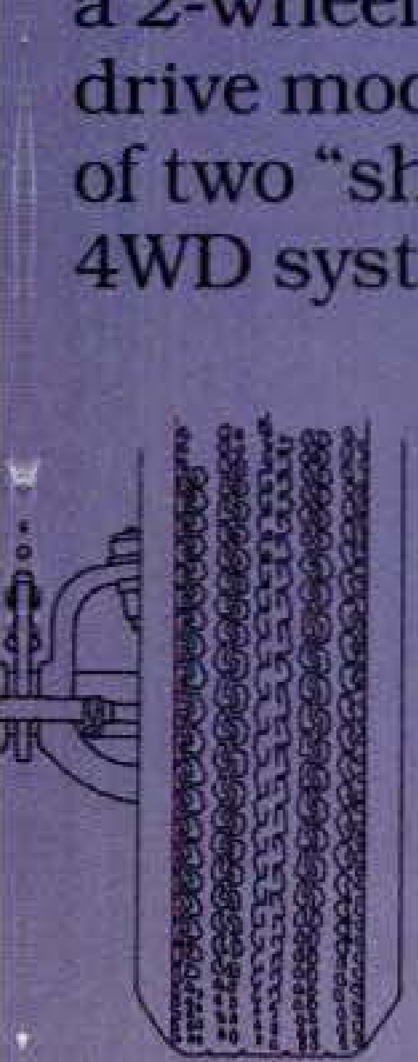

Suspension.

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